MACHINERY.

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ROLLER CHAIN POWER TRANSMISSION AND CONSTRUCTION OF SPROCKETS.

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A. Eugene Michel.

Machined chains and milled sprockets have but recently attained their present high standard. It is therefore not strange that the engineering literature of this country and Europe contains little valuable information concerning them. Ignorance and neglect of mechanical laws have resulted, and the users of chain drives have been subjected to difficulties, many of which may be eliminated by proper construction.

Steel chain of accurate pitch, high tensile strength, and good wearing qualities, possesses, when used within proper limitations, advantages enjoyed by no other form of transmission. It is compact, affords an absolutely positive speed ratio, and at slow speeds is capable of transmitting heavy strains. On short transmissions it is more efficient than belting, and will operate more satisfactorily in damp or oily places. There is

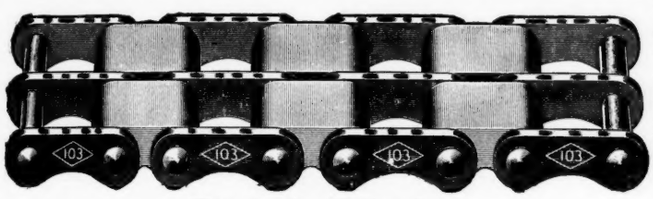


Fig. 1. Double-width Block Chain.

no loss of power from stretch, and as it allows of a low tension, journal friction is minimized. The first cost is little more than that of belting for the same duty. Sprockets cost more than pulleys, but admit of great reduction in size and weight.

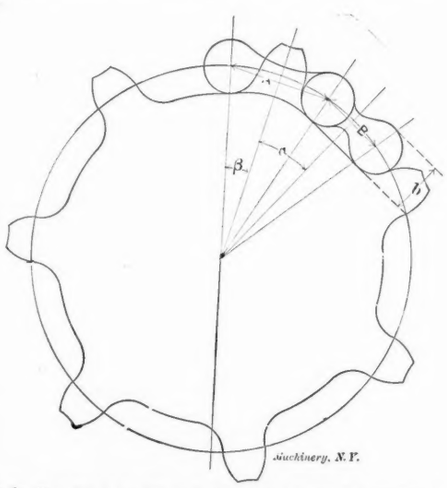


Fig. 3. For obtaining Pitch, Bottom and Outside Diameters of a Block Chain Sprocket.

Roller chain has been known to stand up at a speed of 2,000 feet per minute, and transmit 25 horse power at 1,250 feet per minute; but speeds of 1,000 feet per minute and under, give better satisfaction. Block chain is adapted to slower speeds, say 700 feet per minute and under, and is extensively used on bicycles, small motor cars and machine tools. Where speed and pull are not fixed quantities, it is advisable to keep the speed high, and chain pull low, yet it should be borne in mind that high speeds are more destructive to chains of large, than to those of small pitch.

The following table of tensile strengths, based on tests of "Diamond" chains taken from stock, may be considered a fair standard:

ROLLER CHAIN.

Pitch.	Tensile Strength, Pounds.	Pitch.	Tensile Strength, Pounds.
½ inch	1,200	1¼ inch	9,000
⅝ inch	1,200	1½ inch	12,000
¾ inch	4,000	1¾ inch	19,000
1 inch	6,000	2 inch	25,000

BLOCK CHAIN.

1 inch	1,200 to 2,500	1½ inch	5,000

It is a common fallacy that the safe working load of a chain is close to the ultimate tensile strength. The safe working load is dependent on the amount of rivet bearing surface, and varies from 1-5 to 1-40 of the tensile strength, according to the speed, size of sprockets, and other conditions peculiar to each case. The tendency now is to use the widest possible chain in order to secure maximum rivet bearing surface, thus insuring minimum wear from friction. In the last few years manufacturers have been making heavier chains than heretofore for the same duty. As short pitch is always desirable for high or low speeds, special double and even triple-width chains are

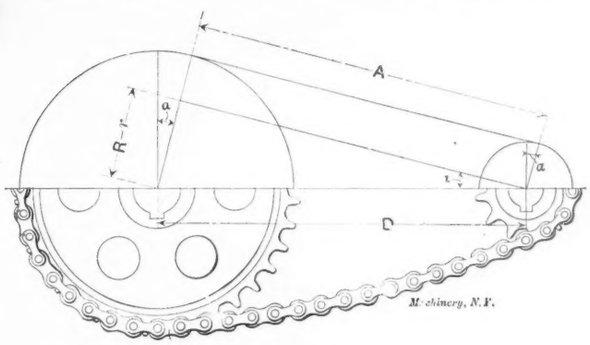


Fig. 2. For Calculating Exact Length of Chain for a given Drive.

now made to conform to the requirements when a heavy single width chain of greater pitch is not practical. Fig. 1 represents such a double chain having twice the rivet bearing surface and half again as much tensile strength as the similar single one.

The exact length of chain for a given drive is not so easily obtained as it seems at first sight. The following formula will be found useful: (See Fig. 2.)

All dimensions in inches.

D = Distance between centers of shafts.

A = Distance between limiting points of contact.

R = Pitch radius of large sprocket.

r = Pitch radius of small sprocket.

N = Number of teeth of large sprocket.

n = Number of teeth of small sprocket.

P = Pitch of chain and sprockets.

$(180° + 2\,a)$ (see Fig. 2) = angle of contact on large sprocket.

$(180° - 2\,a)$ = angle of contact on small sprocket.

$$a = \sin^{-1} \frac{R - r}{D}$$

$$A = D \cos a$$

A. EUGENE MICHEL was born in St. Louis, Mo. 1880. He is a graduate in mechanical engineering of the Rose Polytechnic Institute. Since graduation he spent two years in the engineering department of the Federal Mfg. Co.'s diamond chain factory. He resigned his position with this concern to take charge of the new testing department of the Ewart Mfg. Co., Indianapolis, Ind., and will there direct tests of the Renold silent chain and detachable link belting.

Length of chain required:

$$L = \frac{180 + 2\,a}{360} N P + \frac{180 - 2\,a}{360} n P + 2 D \cos a$$

For *block* chain, the total length specified in ordering should be in multiples of the pitch. For *roller* chain, the length should be in multiples of twice the pitch, as a union of the ends can be effected only with an outside and an inside link.

PITCH DIAMETERS FOR ROLLER CHAIN SPROCKETS.

No. of Teeth.	½" P	⅝" P.	¾" P.	1" P.	1¼" P.	1½" P.	1¾" P.	2" P.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
8	1.307	1.634	1.960	2.613	3.266	3.921	.....	.....
9	1.462	1.827	2.193	2.924	3.655	4.386	5.117	.....
10	1.618	2.022	2.427	3.236	4.045	4.854	5.663	6.472
11	1.775	2.218	2.662	3.549	4.438	5.324	6.212	7.100
12	1.932	2.415	2.898	3.864	4.830	5.796	6.761	7.728
13	2.089	2.612	3.134	4.179	5.224	6.268	7.313	8.358
14	2.247	2.809	3.370	4.494	5.618	6.741	7.864	8.988
15	2.405	3.007	3.607	4.810	6.013	7.215	8.417	9.630
16	2.563	3.204	3.844	5.126	6.408	7.689	8.970	10.252
17	2.721	3.401	4.081	5.442	6.803	8.164	9.524	10.884
18	2.879	3.559	4.319	5.759	7.199	8.638	10.078	11.518
19	3.038	3.797	4.557	6.076	7.595	9.114	10.632	12.152
20	3.196	3.995	4.795	6.393	7.991	9.589	11.187	12.786
21	3.355	4.193	5.033	6.710	8.388	10.064	11.742	13.420
22	3.513	4.392	5.271	7.027	8.784	10.539	12.297	14.054
23	3.672	4.590	5.508	7.344	9.180	11.016	12.852	14.688
24	3.831	4.788	5.746	7.661	9.576	11.492	13.407	15.322
25	3.989	4.987	5.984	7.979	9.974	11.968	13.963	15.958
26	4.148	5.185	6.222	8.297	10.371	12.444	14.518	16.594
27	4.307	5.384	6.460	8.614	10.768	12.921	15.074	17.228
28	4.465	5.582	6.698	8.931	11.164	13.397	15.629	17.862
29	4.624	5.781	6.936	9.249	11.561	13.873	16.186	18.498
30	4.783	5.979	7.175	9.567	11.958	14.350	16.742	19.132
31	4.942	6.178	7.413	9.884	12.355	14.826	17.298	19.768
32	5.100	6.376	7.652	10.202	12.753	15.303	17.853	20.404
33	5.260	6.575	7.890	10.520	13.150	15.780	18.409	21.040
34	5.419	6.774	8.129	10.838	13.548	16.257	18.966	21.676
35	5.578	6.972	8.367	11.156	13.945	16.734	19.522	22.312
36	5.737	7.171	8.605	11.474	14.343	17.211	20.078	22.948
37	5.896	7.369	8.844	11.791	14.739	17.687	20.634	23.581
38	6.055	7 568	9.083	12.110	15.138	18.165	21.191	24.220
39	6.214	7.767	9.321	12.427	15.534	18.641	21.747	24.854
40	6.373	7.966	9.560	12.746	15.933	19.119	22.304	25.492
41	6.532	8.165	9.798	13.064	16.330	19.596	22.861	26.128
42	6.691	8.363	10.037	13.382	16.728	20.073	23.418	26.764
43	6.850	8.562	10.274	13.699	17.124	20.548	23.974	27.398
44	7.009	8.761	10.512	14.018	17.523	21.027	24.530	28.036
45	7.168	8.959	10.751	14.335	17.919	21.503	25.086	28.670
46	7.327	9.158	10.990	14.653	18.316	21.980	25.643	29.306
47	7.486	9.358	11.229	14.972	18.715	22.458	26.201	29.944
48	7.645	9.557	11.468	15.291	19.114	22.937	26.758	30.582
49	7.804	9.755	11.706	15.608	19.510	23.412	27.314	31.216
50	7.963	9.954	11.945	15.927	19.909	23.891	27.871	31.854
51	8.122	10.153	12.184	16.244	20.305	24.366	28.427	32.488
52	8.281	10.351	12.422	16.562	20.703	24.843	28.983	33.124
53	8.440	10.550	12.661	16.880	21.100	25.320	29.541	33.760
54	8.600	10.750	12.900	17.200	21.500	25.800	30.099	34.400
55	8.759	10.949	13.137	17.516	21.895	26.274	30.656	35.032
56	8.917	11.147	13.379	17.835	22.294	26.753	31.211	35.670
57	9.076	11.345	13.614	18.152	22.690	27.228	31.766	36.304
58	9.235	11.544	13.853	18.471	23.089	27.707	32.323	36.942
59	9.395	11.743	14.093	18.790	23.488	28.185	32.882	37.580
60	9.553	11.941	14.329	19.105	23.881	28.658	33.435	38.210
61	9.714	12.142	14.572	19.429	24.286	29.144	34.000	38.858
62	9.873	12.342	14.807	19.743	24.679	29.615	34.554	39.486
63	10.030	12.538	15.045	20.060	25.075	30.090	35.106	40.120
64	10.189	12.737	15.284	20.379	25.474	30.569	35.663	40.758
65	10.350	12.937	15.525	20.700	25.875	31.050	36.224	41.400
66	10.508	13.136	15.793	21.017	26.271	31.526	36.780	42.034
67	10.666	13.332	15.998	21.331	26.664	31.997	37.330	42.662
68	10.827	13.534	16.241	21.654	27.068	32.481	37.895	43.308
69	10.987	13.733	16.480	21.973	27.466	32.960	38.453	43.946
70	11.146	13.932	16.719	22.292	27.865	33.438	39.010	44.584
71	11.304	14.131	16.958	22.609	28.261	33.914	39.566	45.218
72	11.463	14.328	17.194	22.925	28.656	34.388	40.119	45.850
73	11.620	14.525	17.430	23.240	29.050	34.860	40.669	46.480
74	11.779	14.723	17.668	23.557	29.446	35.336	41.225	47.114
75	11.939	14.923	17.908	23.878	29.848	35.817	41.786	47.756

Wherever possible, the distance between centers of shafts should permit of adjustment in order to regulate the sag of the chain. A chain should be adjusted, in proportion to its length, to show slack when running, care being taken to have it neither too tight nor too loose, as either condition is destructive. If a fixed center distance must be used, and results in too much sag, the looseness should be taken up by an idler, and when there is any considerable tension on the slack side, this idler must be a sprocket. Where an idler is not practical, another combination of sprockets giving approximately the same speed ratio may be tried, and in this manner a combination giving the proper sag may always be obtained.

In automobile drives, too much sag or too great a distance between shafts causes the chain to whip up and down—a condition detrimental to smooth running and very destructive to the chain. In this class of work a center distance of over four feet has been used, but greater efficiency and longer life are secured from the chain on shorter lengths, say three feet and under.

Properly proportioned and machined sprockets are essential to successful chain gearing. Sprocket cutting is not difficult, yet strange to say, most American practice is bad. Hence the writer presents these formulas and data to enable any manufacturer to do this work correctly, and at little cost.

The important dimensions of a sprocket are the pitch diameter and the bottom and outside diameters. For block chain these are obtained as follows: (See Fig. 3.)

N = No. of teeth.
b = Diameter of round part of chain block.
B = Center to center of holes in chain block.
A = Center to center of holes in side links.

BLOCK CHAIN SPROCKET DIAMETERS.

Standard Bicycle Chain, 1" Pitch. Diam. of round part of block = .325".			Number of Teeth.	Standard Block Chain, 1½" Pitch. Diam. of round part of block = .532".		
Pitch Diam.	Outside Diam.	Bottom Diam.		Pitch Diam.	Outside Diam.	Bottom Diam.
Inches.	Inches.	Inches.		Inches.	Inches.	Inches.
1.935	2.260	1.610	6	.....	.....	.....
2.250	2.575	1.925	7	.....	.....	.....
2.564	2.889	2.239	8	.....	.....	.....
2.882	3.207	2.557	9	4.323	4.730	3.791
3.198	3.523	2.873	10	4.798	5.205	4.266
3.514	3.839	3.188	11	5.274	5.681	4.742
3.832	4.157	3.507	12	5.749	6.156	5.217
4.150	4.475	3.825	13	6.224	6.693	5.692
4.467	4.792	4.142	14	6.701	7.170	6.169
4.785	5.110	4.460	15	7.177	7.646	6.645
5.103	5.428	4.778	16	7.654	8.123	7.122
5.420	5.745	5.095	17	8.130	8.662	7.598
5.743	6.068	5.418	18	8.607	9.139	8.075
6.056	6.381	5.731	19	9.084	9.616	8.552
6.373	6.698	6.048	20	9.561	10.093	9.029
6.691	7.016	6.366	21	10.039	10.571	9.507
7.008	7.333	6.683	22	10.516	11.048	9.984
7.327	7.652	7.002	23	10.993	11.525	10.461
7.647	7.972	7.322	24	11.469	12.001	10.937
7.966	8.291	7.641	25	11.946	12.478	11.414
8.284	8.609	7.959	26	12.422	12.954	11.890
8.602	8.927	8.277	27	12.900	13.432	12.368
8.919	9.244	8.594	28	13.376	13 908	12.844
9.236	9.561	8.911	29	13.856	14.388	13.324
9.556	9.881	9.231	30	14.330	14.862	13.798
9.874	10.199	9.549	31	14.810	15.342	14.270
10.192	10.517	9.867	32	15.286	15.818	14.754
10.510	10.835	10.185	33	15.764	16.296	15.232
10.828	11.153	10.503	34	16.245	16.777	15.713
11.146	11.471	10.821	35	16.720	17.252	16.188
11.464	11.789	11.139	36	17.196	17.728	16.664
11.782	12.107	11.457	37	17.669	18.201	17.137
12.100	12.425	11.775	38	18.151	18.683	17.619
12.418	12.743	12.093	39	18.627	19.159	18.085
12.736	13.061	12.431	40	19.105	19.637	18.573
			41	19.584	20.116	19.052
			42	20.062	20.594	19.530
			43	20.532	21.064	20.000
			44	21.015	21.547	20.483
			45	21.488	22.020	20.956
			46	21.966	22.498	21.434
			47	22.450	22.982	21.918
			48	22.953	23.465	22.401
			49	23.408	23.940	22.876
			50	23.879	24.411	23.347

$$a = \frac{180^\circ}{N}$$

$$\text{Tan } \beta = \frac{\sin a}{\frac{B}{A} + \cos a}$$

$$\text{Pitch diameter} = \frac{A}{\text{Sin } \beta}$$

Bottom diameter = pitch diameter − b.
Outside diameter = pitch diameter + b.

For roller chain: (See Fig. 4.)

N = Number of teeth.
P = Pitch of chain.
D = Diameter of roller.

$$\alpha = \frac{1}{2} \frac{360°}{N}$$

$$\text{Pitch diameter} = \frac{P}{\sin \alpha}$$

Bottom diameter = pitch diameter − D.

For sprockets of 17 teeth and over,

Outside Diam = Pitch Diam. + D.

The outside diameter of smaller sprockets are cut down so that the teeth will clear the roller perfectly at high speeds.

Outside Diam. = Pitch Diam. + D − E.

Pitch.	Values of E. 8 to 12 Teeth.	13 to 16 Teeth.
½ inch to ¾ inch	.062 inch	.031 inch
1 inch to 2 inches	.125 inch	.062 inch

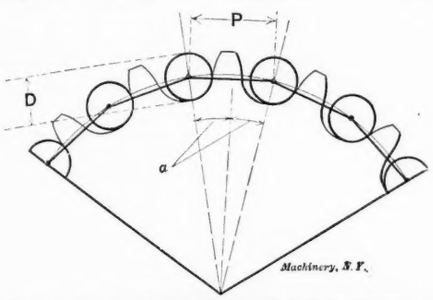


Fig. 4. For obtaining Pitch, Bottom and Outside Diameter of a Roller Chain Sprocket.

The tables of diameters on previous page have been prepared from these formulas.

Sprocket diameters should be very accurate, particularly the base diameter, which should not vary more than .002 inch from the value obtained from the tables. All sprockets should be gaged to discover thick teeth and inaccurate diameters. A poor chain may operate on a good sprocket, but a bad sprocket will ruin a good chain. Sprockets of twelve to sixty teeth give best results. Fewer may be used, but cause undue elongation in the chain, wear the sprockets and consume too much power. Eight-tooth sprockets ruin almost every roller chain applied to them, and ten and eleven teeth are fitted only for medium and slow speeds with other conditions unusually favorable.

Sprocket teeth seldom break from insufficient strength, but the tooth must be properly shaped. A chain will not run well unless the sprockets have sidewise clearance and teeth tapered at the ends. Fig. 5 is a practical shape.

Calling W the width of the chain,

$$A = \frac{W}{2}$$

$B = W$ − 1-64 inch when W = 1-4 inch or less.
$= W$ − 1-32 inch when W = 5-16 to 5-8 inch inclusive.
$= W$ − 1-16 inch when W = 3-4 inch or over.

Note that the curvature at the end of the tooth begins at the pitch line.

If the sprocket is flanged the chain must seat itself properly without the side bars coming into contact with the flange. The following values of C will be found safe:

Chain.	C not less than
1 in. P block, 1 in. P twin roller and ½ inch P block and ⅝ inch P roller	1-4 inch
1½ inch P block and ¾ inch P roller	11-32 inch
1 inch P roller	1-2 inch
1¼ inch P roller	9-16 inch
1½ inch P roller	5-8 inch
1¾ inch P roller	13-16 inch
2 inch P roller	15-16 inch

The principal cause of trouble within the chain is elongation, and this must, as far as possible, be eliminated. It is the result of stretch of material or natural wear of rivets and their bearings. To guard against the former, chain makers use special materials of high tensile strength, but a chain subjected to jars and jolts beyond the limit of elasticity of the material may be put in worse condition in an instant than in months of natural wear. If for any reason a link elongates unduly it should be replaced at once, as one elongated link will eventually ruin the entire chain. Such elongation frequently results from all the load being thrown on at once.

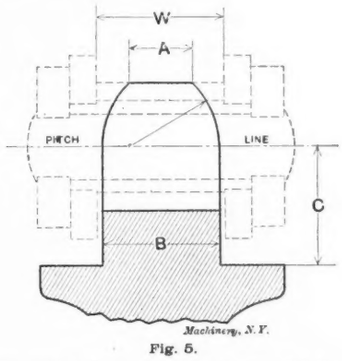


Fig. 5.

To minimize natural wear, chains should be well greased inside and out, protected from mud and heavy grit, cleaned often and replaced to run in the same direction and same side up. A new chain should never be applied to a much-worn sprocket.

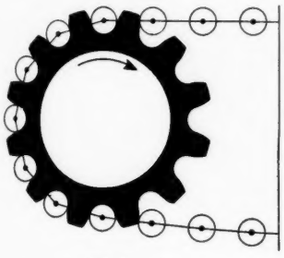


Fig. 6 A.

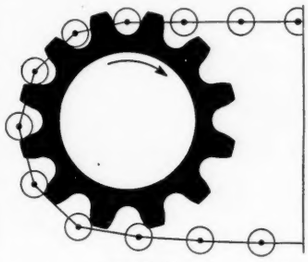


Fig. 6 B.

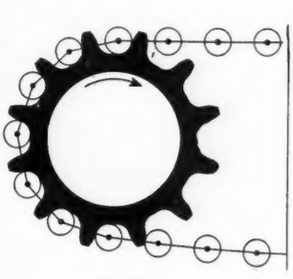


Fig. 7 A_1.

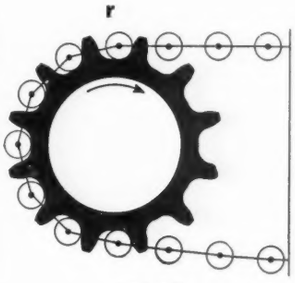


Fig. 7 B_1.

The importance of pitch line clearances is clearly shown in Fig. 6, which represents a sprocket with no clearances.

The new chain, 6A, fits perfectly, but after natural wear, 6B, the pitch of chain and sprocket become unlike. The chain is then elongated and climbs the teeth which act as wedges, producing enormous strain and disagreeable racket, and quickly wrecks itself.

Fig. 7 is the same chain on a driven sprocket, cut with clearances. When new, A_1, all rollers seat against their teeth. After long and useful life, B_1, the working roller, r, has shifted to the top, and the other rollers still seat with the same ease as when new. The chain may still be used until the stage indicated in B, Fig. 6, is reached. B_1 also shows that the chain pull is taken by the one roller, r. Theoretically, all the rollers share the load in the case of A_1. This never occurs in practice, for infinitesimal wear within the chain causes *one, and only one*, roller, r, to bear perfectly seated against the working face of the sprocket tooth at any one time. In Fig. 8, A_2 shows the driver cut with clearance and with a new chain; B_2, the same chain after wear, which demonstrates that clearance alone on the driver will not provide for elongation. To operate properly the pitch of the driver must be lengthened,

which is done by increasing the pitch diameter by an amount dependent upon the clearance allowed.

In Fig. 9, A_3 is a new chain on a driver cut with clearance and increased pitch diameter. The working roller, r, is at the bottom of the sprocket. After the chain wears, B_3, the working roller, r, shifts to the top, and the chain is still good until the condition of B_2, Fig. 8, is reached.

This demonstration is quite true for a drive in which the chain pull is *always in the same direction*, and should be applied for such drives. The theoretical reasoning is intricate, so I shall refer those interested to "Roller Chain Gear," a treatise on English practice, by Hans Renold.

When the load reverses, and this is more frequently the case, each sprocket becomes alternately driver and driven. This happens in a motor car during positive and negative acceleration, or in ascending or descending a hill. In this event, the

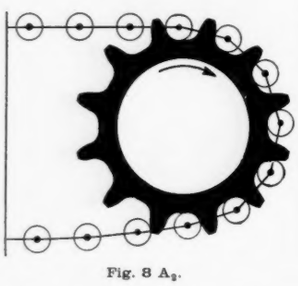


Fig. 8 A_2.

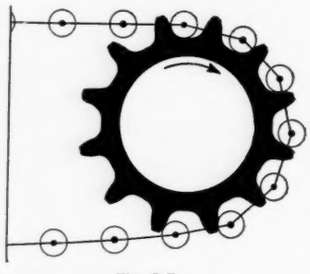


Fig. 8 B_2.

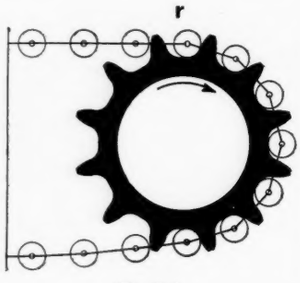


Fig. 9 A_3.

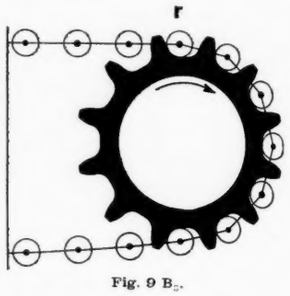


Fig. 9 B_3.

above construction is not applicable, for a driven sprocket of longer pitch than the chain will stretch it. No perfect method of equalizing the pitch of a roller chain and its sprockets under reversible load and at all periods of chain elongation has been found. This fault is eliminated in the "silent" type of chain; hence it runs smooth at a very much greater speed than roller chain will stand.

In practice there are comparatively few roller chain drives with chain pull always in the same direction, so manufacturers generally cut the driver sprockets for these with normal pitch diameter, same as the driven. Recent experiments have proven that the difficulties are greatly lessened by cutting both driver

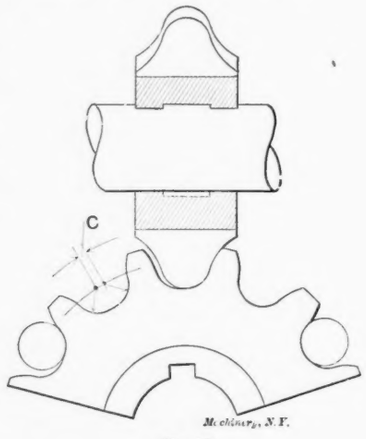


Fig. 10.

and driven with liberal pitch line clearance. Accordingly, chain makers now advise the following pitch line clearance (C in Fig. 10) for standard rollers:

Pitch.	Clearance.
½ inch and ⅝ inch	1-32 inch
¾ inch	1-16 inch
1 inch	3-32 inch
1¼ inch	3-16 inch
1½ inch	7-32 inch
1¾ inch	1-8 inch
2 inch	5-32 inch

Cutters may now be obtained from B. & S. with this clearance, but their former cutters have only from .015 inch to .030 inch or none at all. To obtain the proper clearance with the older cutters, mill the sprocket, as usual, revolve it a sufficient amount to make the clearance conform with the above table, measuring on the pitch line (Fig. 10) and take an additional cut around. The base diameter should remain as figured from the pitch tables.

The above clearance table is figured for American and English standard size rollers, and will not apply to the Whitney standard. With this latter, it is not possible to obtain so much clearance on the 1, 1¼ and 1½-inch pitch without weakening the tooth beyond a safe limit.

There is yet much to be learned about roller chains and the pitch line clearances of their sprockets, but the hints herein given should enable chain users to obtain better results from their drives.

* * *

The use of nickel steel is becoming more and more extensive. In a report on the subject of steel hardening metals by Mr. Joseph H. Pratt, in the United States Geological Survey, it is stated that over 11,000 tons of nickel steel rails were manufactured in 1903. These rails were used on the Pennsylvania, Baltimore & Ohio, New York Central, Erie, Chesapeake & Ohio, and Bessemer & Lake Erie railroads. They are largely used on sharp curves where their value was first demonstrated by the Pennsylvania R. R. on the famous Horse Shoe Curve, near Altoona, Pa. From experiments made on this curve, it appears that nickel steel rails will outlast four ordinary steel rails. Nickel steel is also being extensively used where a non-rusting metal of high tensile strength is required. Nickel steel containing from 25 to 30 per cent nickel resists rust to a remarkable degree. It is being used in mines, for torpedo defense netting, umbrella wire, corset stays, condenser and boiler tubes, and many other purposes where steel is subjected to dampness. Not the least important feature of these nickel steel alloys containing a high percentage of nickel is the remarkable decrease in the coefficient of expansion. In fact with the alloy known as invar, the coefficient of expansion is nearly zero. By varying the proportions of nickel and steel the coefficient of expansion may be changed to agree with that of other metals, as for instance, platinum. Hence it is being substituted for platinum, which is very expensive, in the manufacture of incandescent lamps. Platinum happens to have practically the same coefficient of expansion as glass, which makes it possible to use it for the terminals which must pass through the glass. With other metals having a different coefficient of expansion the glass will crack, or the terminals will be loose, thus allowing leakage of air and destroying the high vacuum necessary to the success of the incandescent lamp.

* * *

A device known as the de Forest wireless ship localizer, the aim of which is to warn ships of their nearness to dangerous points, will be given experimental trial shortly on the Great Lakes. Ships so warned will have to carry wireless telegraph apparatus. For the tests on the lakes it is intended to install 52 automatic stations at the points of greatest danger to ships. These stations will operate continuously upon the approach of fogs or storms, and their effect will be felt for about six miles. Each will have its own characteristic call, so that an operator at a wireless instrument on shipboard hearing such a call will know that he is within six miles of the given locality. The intensity of the call increases as it is approached. The instrument on board ship for receiving the call is equipped with a long flat screen, pivotally mounted, in place of the antennæ wires usual in wireless telegraphy. By constantly turning the screen while the signals are being received, the direction from which the call comes may be indicated.

A REVIEW OF STEAM TURBINE PATENTS.—4.

Richard Schultz, 1900.

This invention, shown in Fig. 53, cannot be regarded other than as a modification of Pyle's turbine of 1895. Steam passes longitudinally through the wheel several times, as indicated in the engravings. *A* and *B* are two wheels attached to the shaft; *C* is an intermediate stationary disk with guide passages, and *E* and *F* are stationary castings for reversing the direction of flow of the steam after it has passed through the passages of the wheels and guides, and directing it back through the next series of passages. In addition, he provides for a series of vanes for reversing the direction of motion against which steam flowing through the pipe at *G* impinges.

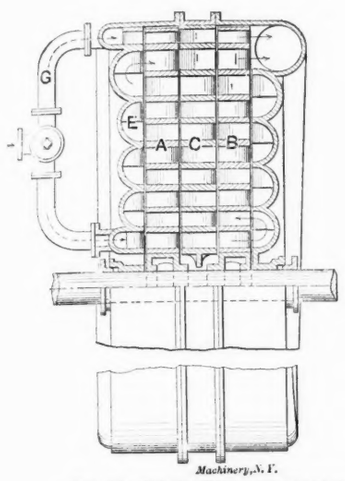


Fig. 53. Schultz Reversing Turbine.

Zoelly, 1900.

The group in Fig. 54 shows certain features of construction for turbine wheels covered by two patents issued to Heinrich Zoelly, Zurich, Switzerland, one in 1900 and the other in 1903. The inventions relate to wheels with radial arms, the outer ends of which serve as vanes for the wheel. These arms decrease in cross-section as they approach the periphery of the wheel and thus are proportioned to resist centrifugal force in such a way as to produce a uniform stress per square inch throughout their length.

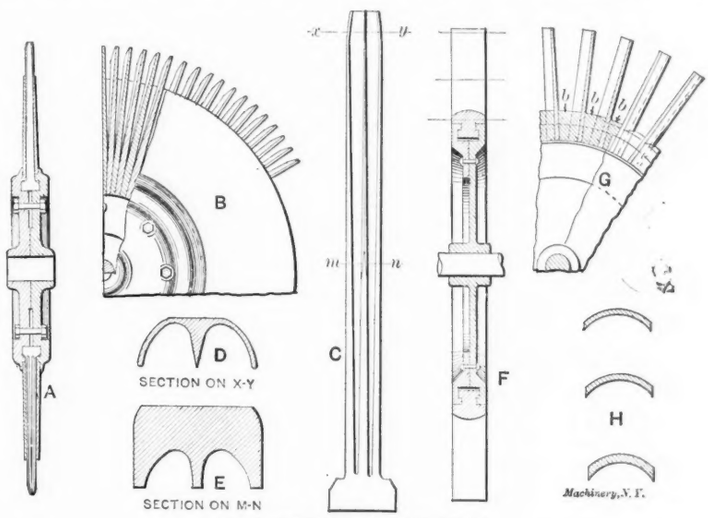


Fig. 54. Wheels Patented by Zoelly.

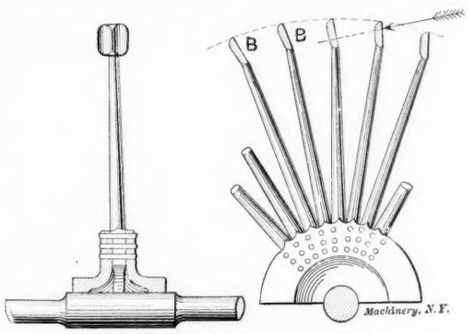


Fig. 55. Richards' Pelton-type Wheel.

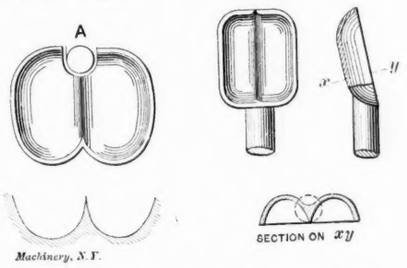


Fig. 56. Buckets proposed for Richards Wheel.

The patent of 1900 is for a design of turbine blades suited to the Pelton type of wheel in which the stream is projected against the faces of blades which have a central rib to divide the stream and cause it to turn through nearly 180 degrees and discharge on each side of the wheel. The first claim of this patent is for "the combination in a turbine wheel of radial buckets separated from each other for a part of their length, each bucket having its receiving face channeled for the greater portion of its length, and a pair of flat disks inclosing said buckets from their inner ends for a greater portion of the length of the channeled part of the buckets." In Fig. 54, *A* and *B* are two sectional views of the wheel, *C*, an enlarged front view of one of the blades, and *D* and *E*, enlarged sections of the blade on the lines *x y* and *m n* respectively. At *F* and *G* are details of a wheel now used in the Zoelly turbine and already described in MACHINERY. In this type, the steam is directed against the blades on one side of the wheel and escapes on the other side. Sections of the blades are shown at *H*. The first claim is for a "turbine blade constructed with a gradually increasing longitudinal thickness and a longitudinal cavity of substantially uniform depth." Some of the other claims relate also to the method of clamping the blades in position, and the use of spacing blocks, *b b*, between them.

Richards, 1902.

The idea presented in the Zoelly patent of 1900 is carried a step further in a patent issued to J. Richards for a Pelton type of wheel, Fig. 55. The wheel consists of buckets, *B*, light in weight and drop forged on the ends of radial arms, which are attached to a central nave by pins inserted between the arms, as indicated in the illustration. The buckets are spaced further apart than is usual in turbines, because they are designed to be concave and reactive through a considerable angle of rotation, and thus will absorb the energy of the jet sufficiently throughout this range. The arms of the wheels are not covered by plates at the sides, as in the Zoelly design, the intention of the inventor being that the inside of the turbine casing shall be machined smooth, and the steam allowed to rotate with the wheel within the casing. The claim is in substance for a wheel having a single hub, of a diameter within the zone of disruptive centrifugal strain, with equidistant radial sockets formed therein; strong radial stems fastened in the sockets; and concave reactive buckets integrally formed on the extremities of the stems.

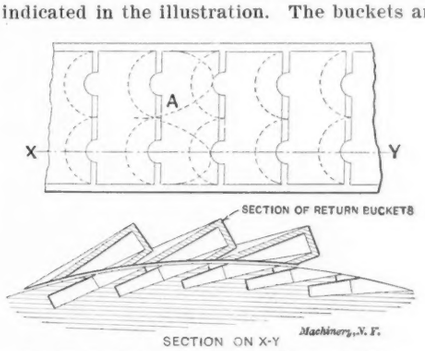


Fig. 57. Buckets and Guides for Stumpf Turbine.

Stumpf, 1903.

The Pelton type of wheel devised by Prof Stumpf contains double U-buckets with a dividing ridge, milled out from the solid rim of the wheel and taking the form shown in the plan and sectional views of Fig. 57. He proposes to use a series of guide passages having the general contour of the dotted line shown at *A*, which gather up the steam after it has issued from the two sides of the wheel and return it in a single, solid stream at the center, where it impinges a second time against the blades of the same wheel. In Fig. 58 is shown a modified form of the guides having partitions extending in the direction in which the steam flows, for the purpose of insuring equal division of the steam jet over the whole breadth of the return buckets, with a view to preventing choking of the steam at the point where it strikes the wheel vanes.

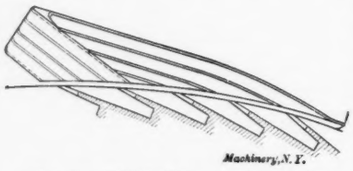


Fig. 58. Modified Form of Guides for Stumpf Turbine.

It is pointed out by Prof. Stumpf that steam, in reversing its direction of flow in a turbine wheel, acquires sufficient centrifugal force to increase its pressure, frequently by a considerable amount, so that in leaving the vanes there is a sudden explosive expansion of the steam, causing a scattering of the jets. By catching the steam in the return buckets as it leaves the wheel, and bringing the streams together in a solid jet again at the center, he aims to overcome this action and to produce a more efficient type of compound turbine. His claims are broad ones, applying to the combination of admission nozzles, a turbine wheel with double buckets and double return buckets.

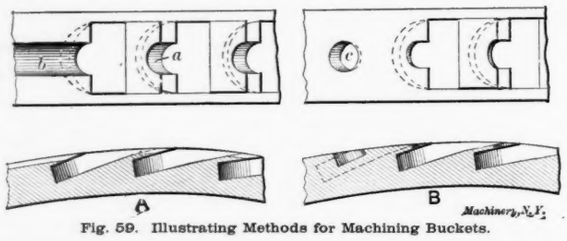


Fig. 59. Illustrating Methods for Machining Buckets.

In connection with the Stumpf patent, one issued in 1904 to Kaufhold and Hoffmann, and assigned to the manufacturers of the Stumpf turbine, relates to the process of cutting out the buckets. In order to insure a change in direction of the fluid of 180 degrees it is necessary that the grooved portion of the recess should complete a full half circle, and this is easiest accomplished by means of a disk milling cutter. In using such a cutter, however, it is necessary to cut out a circular portion of the rim, to allow room for the cutter arbor, as indicated at *a* in Fig. 59. One method of doing this is to use a stepped milling cutter, one part of which cuts the larger recess and the other part the smaller recess for the arbor. The methods covered by the patent, however, consist first in turning a groove, *b*, in the rim of the wheel before milling the recess, which obviously will accomplish the desired end. The other method is to drill holes in the rim, as shown at *c*. The inventors prefer either of these methods to the use of the stepped cutter method.

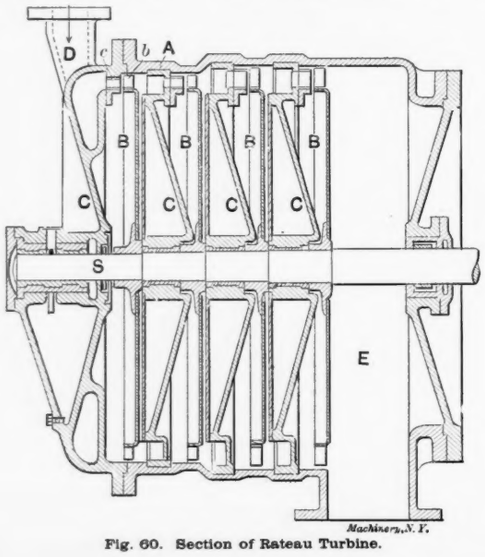


Fig. 60. Section of Rateau Turbine.

Rateau and Sautter, 1903.

The Rateau turbine, the main principles of which are covered by this patent is, like the invention of Moorhouse, 1887, an impulse turbine consisting of a number of wheels upon which the steam acts in succession, each wheel being in a separate compartment. In Fig. 60, *A* is the turbine casing, *B B*, etc., are the rotating wheels attached to the shaft, *S*, and *C C C* are diaphragms forming the separate compartments. Steam enters through the intake pipe at *D*, passes between a series of guide vanes at *c*, where it is directed against the vanes, *b*, of the first wheel. It then passes through the guide vanes in the next diaphragm and impinges against the next wheel, and so on, until the exhaust space, *E*, is reached. The depth of the guide blades and wheel vanes increases progressively from the inlet to the outlet, to allow for the increasing volume of the steam.

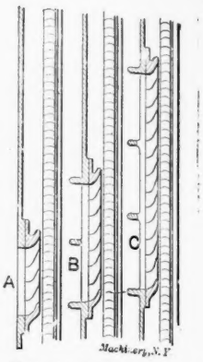


Fig. 61. Arrangement of Guides in Rateau Turbine.

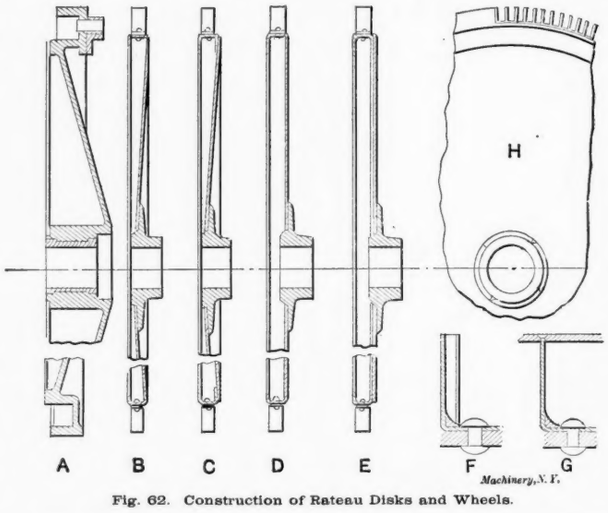


Fig. 62. Construction of Rateau Disks and Wheels.

The principle of this turbine as thus far outlined is in no way different from that of Moorhouse; but Rateau has introduced a principle in the arrangement of the vanes which is new and is covered by this patent. In Fig. 61 the first set of guide blades is shown at *A*. These are few in number and are arranged in, say, three groups about the periphery of the first disk. After passing through the wheel the next set of guide blades is reached at *B*, which consists of a greater number to accommodate the increasing volume of the steam, and these blades are arranged so as to extend by the first set in the direction in which the steam flows, as shown. When the steam reaches the first wheel it will be carried along a short distance by the rotation of the wheel before discharging into the wheel chamber, and a portion of the next set of guide blades should be located in advance of the previous set. At *C* the third set laps by still more, and finally a point will be reached where the blades will extend around the full periphery of the casing. The advantage of this arrangement over one in which steam is first admitted to the turbine around the whole periphery is that the steam at the admission point is comparatively small and the vanes would necessarily have but little radial depth at that point if they comprised a full circle, and there would be excessive friction of the steam when flowing through them. In the Rateau arrangement the steam passages are deeper and the volume of steam passing is large, in proportion to the rubbing surfaces of the vanes. The reference to this in the claims of the patent is as fol-

lows: "* * * distributors arranged in the membranes to direct the motive fluid directly upon the paddle blades, and said distributors increasing in width, and overlapping each other successively at one end and not at the other." Rateau also introduces features of construction on which claims are made, but which are in no way tied with the blade arrangement mentioned above. Some of these are shown in Fig. 62. At *A* is one of the diaphragms containing the guide vanes. At *B*, *C*, *D*, and *E* are typical wheels consisting of steel disks either flanged around their peripheries or else with annular channels riveted to their peripheries. In the first two instances, *B* and *C*, the disks are dished to add to their lateral strength and in the last two they are flat.

The vanes, which are curved suitably at the points where the steam strikes, are bent on an angle and riveted to the circumference of the disk. At *F* and *G* are enlarged details of the vanes, the second one showing a band or shroud riveted to the outer circumference.

Levin, 1904.

A type of wheel in which the steam is expanded completely in a nozzle before impinging against the buckets of the wheel and then is used several times in succession upon the blades of the same wheel. Steam is expanded in the nozzle, *N*, which projects it against one side of the semi-circular buckets, *B*, of the wheel. The steam passes around these buckets and is projected outward against the curved surface, *C*, of the casing twice in succession, which each time redirects the steam

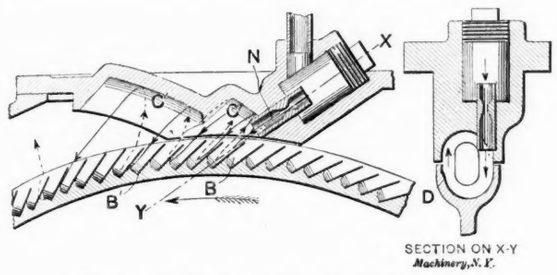


Fig. 63. Single-wheel Compound Turbine of Levin.

against the buckets of the wheel. The curved surface of the casing is stepped so that the portion at *C'* may be brought nearer to the wheel, and when the steam reaches the buckets located at *B'* it is returned against the surface at *C'*. As drawn, the arrangement is designed for a wheel having a peripheral speed of one-tenth the initial velocity of the steam since the steam is projected against the buckets five times in succession. The buckets are semi-circular in form.

At *D* in the right-hand sketch the sides of the buckets are cut away to allow the steam, which has become compressed in its impact against the wheel surfaces, to expand back to its original volume. The steam proceeds in a succession of helical whirls after leaving the nozzle, and it is necessary that the steam should be completely expanded in the nozzle so that it will be at constant pressure, but have a decreasing velocity after leaving the nozzle. The first claim for this wheel is for a "multiple impulse turbine, comprising a wheel having a row of buckets, an expansion nozzle delivering into said buckets, and a stationary reversing guide extending from said nozzle over a number of said buckets, to form a space open end to end within which the motive fluid proceeds in a helical whirl and is successively projected against the buckets of said wheel."

Hodgkinson, 1904.

It has been customary in the Parsons type of turbine to use by-pass valves to supply high-pressure steam to an intermediate point in the turbine where the pressure is normally lower than at the beginning, in order to temporarily increase the power of the turbine. The operation of the valves has usually been by hand, and the patent in question relates to an automatic valve for accomplishing the same end.

In Fig. 64, *A* is the steam inlet and *B* is a valve admitting high-pressure steam, when the valve is raised, to the space *C*, which connects with the intermediate part of the turbine. This is shown in Fig. 65, where steam enters at *A*; *B* is the valve, and *C* is the pipe leading to the turbine.

The valve, *B*, is hollow, allowing the steam to pass through to the space, *D*, where it presses against the under side of the piston, *E*. *F* is a small passage leading from space, *D*, to the space, *H*, so that under ordinary conditions there will be a balanced pressure on the piston, *E*, and the valve will be kept seated by the spring, *S*. Connecting with the space, *H*, in which the spring is located, is a pipe, *P*, leading to a by-pass

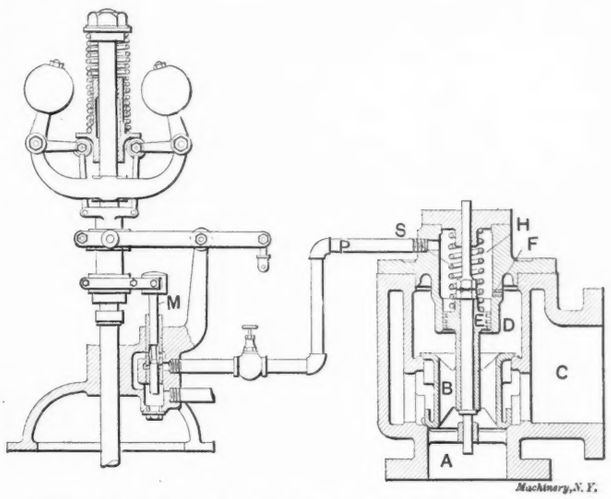


Fig. 64. Valve for Admitting High-pressure Steam to Low-pressure End of Turbine.

in the base of the governor, shown at the left, which is opened or closed by a pilot valve, *M*, under control of the governor. Under normal conditions the pilot valve will be in the position shown, closing the by-pass and preventing the escape of steam from the chamber, *H*. Should the speed of the engine decrease beyond a fixed point, however, the governor balls would move inward, which would depress the governor yoke and the pilot valve, *M*, causing the by-pass to open and allow

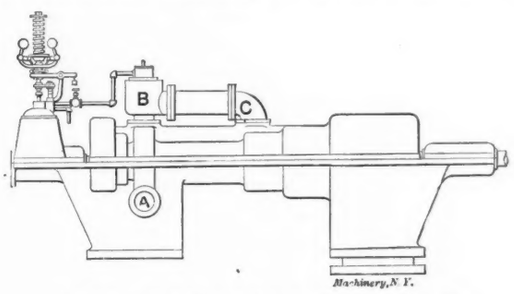


Fig. 65. Showing Connections for By-pass of Fig. 64.

steam to escape from space, *H*, into the atmosphere or condenser. The result would be an unbalanced pressure on the piston, *E*, causing it to raise and compress the spring and open the valve, *B*, allowing the high-pressure steam to enter the low-pressure part of the turbine and increase the power.

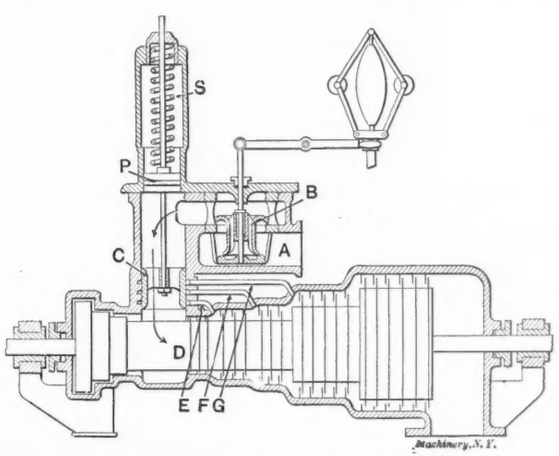


Fig. 66. Brown's Governing Arrangement.

Brown, 1904.

Another patent for accomplishing the same result as with the Hodgkinson invention, in regulating the speed of a turbine by supplying high-pressure steam to the low-pressure passages under heavy loads, is that of C. E. L. Brown, of Brown, Boveri & Co., Switzerland. His invention consists in providing pipes from the steam chest to intermediate stages of the turbine and controlling the openings of these pipes by a valve operated by the governor.

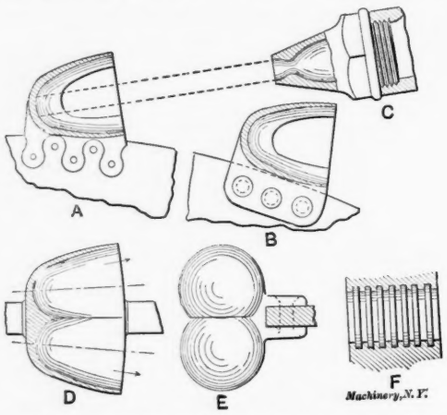


Fig. 67. Pelton Type of Buckets used by C. V. Kerr.

In Fig. 66, steam is admitted through the supply pipe, *A*, and when the throttle valve, *B*, is raised by the governor, steam will pass in the direction of the arrows through the valve, *C*, to the steam space, *D*, whence it will enter the high-pressure end of the turbine. The pipes, *E*, *F*, and *G*, leading to other points in the turbine, are opened to the steam space by movement of the valve, *C*, which uncovers the several ports in succession, when it is raised. Ordinarily, it is kept in its lowest position by the spring, *S*, thus closing all the ports. If, however, the speed of the turbine increases under a heavy load the governor will admit a greater quantity of steam through valve *D* to the steam space, increasing the pressure in the steam space and forcing the piston, *P*, upward against the pressure of the spring, by this means raising the valve, *C*, and admitting steam successively to the different stages of the turbine. Brown's patent also covers an arrangement, for a similar purpose, having the valve, *C*, controlled directly by the governor.

C. V. Kerr, 1904.

The compound impulse turbine, which is the subject of Mr. Kerr's patent, has buckets somewhat of the form of the Pelton water-wheel bucket. They are to be made of drop

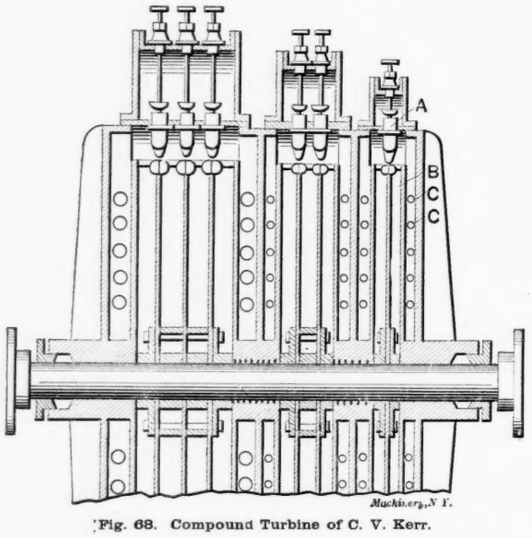


Fig. 68. Compound Turbine of C. V. Kerr.

forgings and of such a shape that they may be bored out perfectly smooth by means of a special reamer. Accordingly, each recess in the bucket on either side of the dividing wedge has a contour representing a surface of revolution. Sketches of the buckets appear in Fig. 67. The curves of the interior of the bucket in a transverse direction must obviously be circles in whole or in part, as shown at *E*, whereas the longitudinal section will show curves elliptical in shape.

The buckets are attached to steel disks, and in order to withstand the great strain he prefers to attach them, as shown at *A*, by dove-tailing and upsetting the interlocking parts, or else by electric welding. Another construction suggested is by riveting, as shown at *D*. Expansion nozzles are used, of the form indicated at *C*, Fig. 67, the tip of the nozzle being rather short inasmuch as the turbine is divided into stages and only a portion of the pressure of the steam has to be reduced at each stage. Each nozzle of the turbine is controlled by a hand valve.

In Fig. 68 is a partial longitudinal section of three stages, although ordinarily it would be constructed with six or more. As the steam progresses through the turbine an increasing nozzle area must be provided, and this the inventor prefers to accomplish partly by multiplying the number of disks in each space rather than by depending entirely on an increase of the areas of the individual nozzles. In the sketch *A* is one of the first series of nozzles, *B* is the first wheel, and *C C*, etc., are openings allowing the steam to pass from the first chamber to the next set of nozzles through a passage cored in the casing. The shaft is provided with a series of rings interlocking with a series of grooves in the partition between each chamber, as shown at *F* in Fig. 67. The object of these is to reduce leakage.

* * *

The U. S. consul at Birmingham, England, says that British industries are being rapidly rebuilt and reorganized on American lines. He complains that many British manufacturers or their representatives have visited America and, having been hospitably received by our manufacturers, have not hesitated to avail themselves of all possible information that would be helpful to them in putting their plants on a competing basis. He says that many young English graduates of the scientific classes of British universities and technical schools who are the sons of manufacturers, merchants, or professional men, are at work in American factories learning all they can about our methods. In this Consul Halstead sees a great national danger as in the movement he sees very little that is nationally reciprocal. Although American methods are condemned by the British technical press, and our products characterized as being "bad," "frail," "defective," "flimsy," etc., there are many Americans managing English factories and introducing the same systems which make American products formidable competitors in the marts of commerce. For instance, one American is now manager of a big British bridge company, and another is superintendent of the same works. With all the conservatism of the British manufacturers, it appears that some of them are outdoing American manufacturers in the matter of scrapping obsolete machines and of installing new and improved machinery in their stead. Hence the inference that the American manufacturer, who looks upon the markets of the world as his to exploit, must count upon an "Americanized" competition which hitherto has been unknown.

There is a whole lot of conceit and egotism in this view of foreign competition for American manufacturers who have no monopoly of new or original ideas, and it is wholly likely that British manufacturing concerns would have reorganized their plants without the stimulus of American ideas, if need be. It smacks somewhat of injustice to deny the right of foreign manufacturers to get new ideas wherever they can, for it is something that we have always done and are doing to-day. Industrial conditions change in all countries but more slowly in old than in newer sections, because of the inertia of investments. Perhaps one of the principal causes for our unexampled progress has been the absorption of foreign ideas unhampered by the fear of impairing the value of existing investments, which was and is now the case in older countries. We have taken whatever seemed good with no qualms as to its origin, but have not been imitators. If foreign concerns imitate us they will not be formidable—if they imitate and originate they will.

THE DESIGNING AND MAKING OF BELLS.

F. P. LOTZ.

F. P. Lotz.

The production of church bells is an art of uncommon interest. Few people understand it at all, and hence it excites the liveliest interest when attention is drawn to it even in an indirect way. How closely bells are united to the human feelings, the begrimed workmen who make them hardly appreciate. We laugh with their merry wedding peals, weep with their somber funeral toll, and, if we are night workers in a great city, we roundly abuse them when their clanging disturbs our Sunday morning slumbers. Everybody that has ears and is not deaf has been enthused and alarmed, has laughed or cried at the sound of the bells, but few persons have any idea of how they are manufactured.

Sometimes they are called brass bells and occasionally bronze bells, but strictly speaking, neither term is correct. Brass is a combination of various metals such as copper, tin, lead, and zinc; bronze, much used in art statuary, is composed of the same metals, but not in the same proportions. Bell metal is entirely different in composition for it consists of only two metals, namely, pure copper and pure tin. Any addition of another kind of metal is an adulteration and always has an injurious tendency. The best tone effect in bell metal is, strangely enough, confined within very narrow limits, for any so-called bell metal having more than seventy-eight parts copper to twenty-two parts tin is too soft to produce the best quality of tone, while that having more tin than twenty-three parts in the 100 is too brittle and hence not safe. The old German bell founders used to make their bells of eighty parts copper to twenty parts tin, and bells are still made of that composition, but they lack brilliancy or "tone color."

The primary art of bell casting is in "drawing it" accurately as to shape so as to secure the best acoustic proportions. I believe each founder has his own rules for this work,

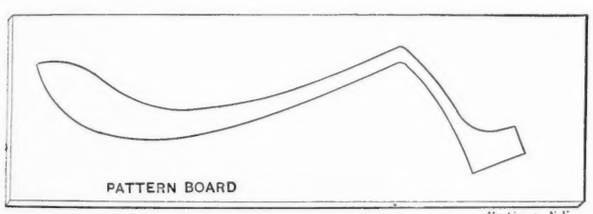


Fig. 1. Drawing of one-half of Bell.

but as they are in a large measure trade secrets, it is hardly expedient for me to discuss them here. The first step in making a bell sweep is to draw the pattern and for this purpose a good straight-grain white pine board of sufficient length and width is chosen and dressed down to about three-eighths of an inch in thickness. When the bell is drawn on this board it looks like Fig. 1. The rule for securing the peculiar empirical shape of the bell is in some respects quite complex, and there are different ways of obtaining the desired curves, since each founder has his own formula according to his own notion of accuracy. For the sake of convenience I will give an example of a process used in England a half century or more ago, for, of course, no one expects me to tell exactly my process for drawing the shape of the bell which I prefer, though I have my preference, of course, with reference to shape and acoustic properties involved. We must first determine upon the size of the bell, which must be mathematically calculated with reference to the note required, but I will not discuss this question because it involves technicalities which I do not think will much interest anyone outside the trade. We begin by drawing a horizontal line, *SL*, representing the diameter (see diagram, Fig. 2), and a perpendicular line, *C*, representing the center of the bell, and we then lay off the outside diameter of the half section by drawing the perpendicular line, *OD*. Using the proportions of the drawing rule or formula, we now proceed to stick pins on the line *OD*, as shown by the figures 1, 1, and 3, and stretch a strong thread from the two pins 1 and 1 around the pin 3; when this is done and the string firmly tightened (see *AA*), pin 3 is withdrawn and a pencil is set at that point held firmly in a perpendicular position keeping the string taut. Carrying the pencil down as indicated by the dotted line, *aa*, it will form the quarter of an ellipse shown by the heavy dotted line, *AA*, which is the inner shape or curvature of the bell. To make the outside curvature or shape, the same process is followed shown by the lines *BB*, and in stretching the string with the pencil, as per the partly dotted line, *bb*, the outside curve, shown by the heavy black line ending at *K* is formed. This leaves only the outside curve of the soundbow to be drawn, and this is done by following another part of the formula and forming the section of a circle, *HG*, by means of a compass. There now remains a small space, *W*, to be closed up, which is done by hand, in accordance with any convenient process, for the section is so small that no particular rule is necessary.

The crown or top of the bell, indicated by *Z* and *V*, is then drawn according to any formula. The crown top, *T*, has nothing to do with tone, but may be of any shape or device which

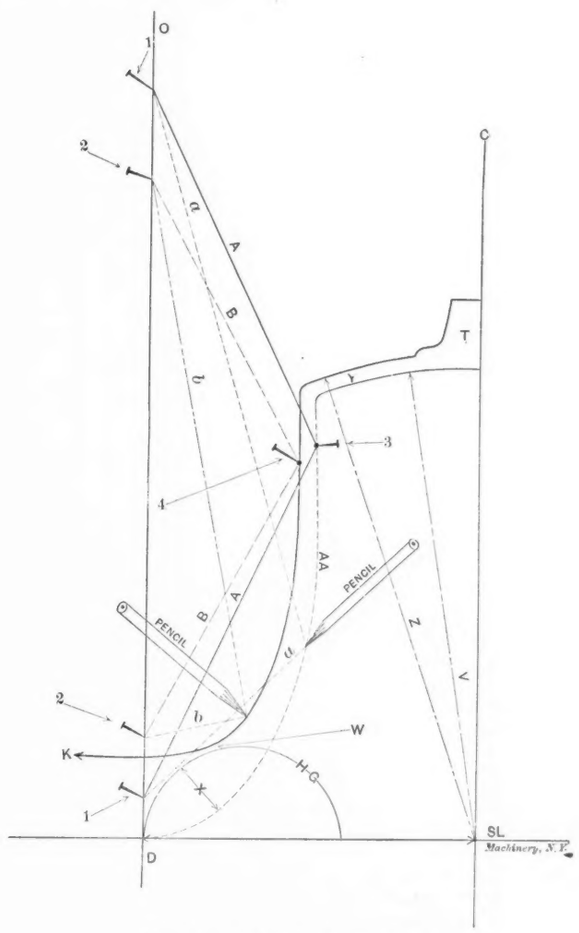


Fig. 2. Method for Laying out a Bell.

pleases the founder as long as it secures a good, safe method of hanging and swinging the bell. Safety is the first consideration, and it is obvious that a bell suspended by only one bolt, no matter what the thickness of the bolt, is not entirely safe. In all continental and English bells there are numerous bolts, and none of the European founders think of hanging the bell on one bolt only. I have often read of bells attached

F. P. Lotz was born in Baltimore, Md., in 1850. He took a course in business college and a correspondence course in literature, and his education outside of this was acquired by persistent study at home. He has been in the employ of the Henry McShane Mfg. Co., Baltimore, Md., the E. W. Van Duzen Co., Cincinnati, O., and Meneely & Co., West Troy, with whom he is at present. Mr. Lotz has contributed quite extensively to encyclopedias and to various New York, Boston and Cincinnati publications.

to the swinging yoke by but one bolt, which suddenly parted, and the bell dropped, making sad havoc in the tower. For this reason, if for no other, churches should select a bell held securely by two or more bolts.

The bell drawing or section is now complete, and the next step is to cut it out and make the two sweep patterns correspond with the inside and the outside shape respectively. This rule or process will make the bell at *Y* one-third of the thickness at *X*, which is the "soundbow" or thickest part of the bell, and is the point where the clapper strikes. The sweep

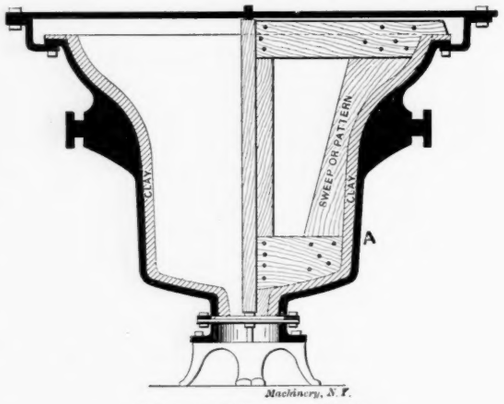


Fig. 3. Bell Sweep and Mold.

board or drawing which represents the outside shape of the bell will have little projections, which the founders call "beads"; these make little grooves in the molds and form the adorning lines on the surface of the bell, relieving what would otherwise be an unbroken smooth surface. These lines are seen in Fig. 4, which shows a finished bell. Fig. 3 shows a sectional view of a bell mold with the sweep or pattern inserted in working shape. The outer section, *A*, is an iron flask liberally perforated so as to give vent to the gas which is generated while pouring or casting the bell. This gas ignites and burns away, thus relieving internal pressure and obviating an otherwise possible explosion. Over the surface of the flask a layer of wet loam of equal and suitable thick-

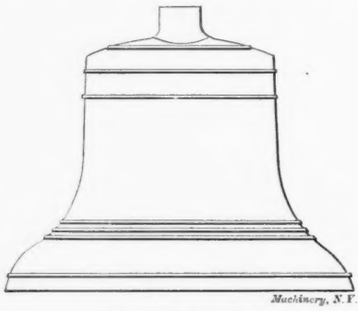


Fig. 4. Finished Bell.

ness is coated and baked, then another layer is coated on and baked, and so on, layer after layer, until the proper shape is secured. There are two such iron molding cases or flasks fitting one over the other, as shown in Fig. 5. The under one has its loam coating on the outer side, which has the inner shape of the proposed bell, while the upper iron molding flask has the loam on the inner surface, and forms the outside shape of the bell which is let down over the under mold and carefully adjusted all around, leaving a space inside between the two molds. The under flask is called the core, the upper or outer one the case; the space between these is filled up by the molten bell metal which, when cooled, is the bell. When the bell is taken out of the molds, it is polished and the hangings—tongue or clapper, etc.—fitted to it. It then receives several ringing tests to ascertain its tone and resonant quality and to observe its

Fig. 5. Iron Flask consisting of "Case" and "Core"

mechanical excellence and adjustment, after which, if it appears to be good in all points, the bell is shipped to the purchaser. The making and shipping of a bell usually require from ten to fifteen days in the smaller sizes, but the larger sizes—of 1,500 pounds and heavier—require more time. A peal of bells takes from forty to ninety days' time, while to make a chime of nine or more bells, from three to six months' time must be allowed.

* * *

NOTES ON LUTES AND CEMENTS.*

Luting and cementing materials for various purposes in the laboratory and shops may be classified as follows:

1. Water- and steam-proof.
2. Oil-proof.
3. Acid-proof.
4. Proof to hydrocarbon gases
5. Chlorine-proof.
6. Elastic.
7. General purposes.
8. Marine glue.
9. Gaskets.
10. Machinists'.
11. Leather (belting).
12. Crucible, iron, and stone
13. Core compounds.
14. Briquetting.

1. *Water-Proof Compositions.*—Of use to engineers are the asphalt fluid coatings for reservoir walls, concrete foundations, brick, wood, etc. Asphalt only partly dissolves in petroleum naphtha, but heated in a steam-jacketed kettle and not thinned out too much, a mixture of the two may be obtained in which the part of the asphalt not dissolved is held in suspension. Asphalt is entirely soluble in benzol or toluol, which are about the cheapest solvents for all the constituents of asphalt. Tar and pitch are sometimes used in this connection, but tar contains water, light oils, and free carbon, and does not wear as well as good refined asphalt; and pitch contains free carbon, which is sometimes objectionable when thinned out with a solvent. The asphalt alone is somewhat pervious to water, and this is improved by adding about one-fourth its weight of paraffin, and made better if in addition a little boiled linseed oil is added also. For thicker compositions, where body is required, asbestos, stone powder, cement, etc., may be added as fillers. Lutes of linseed oil thickened with clay, asbestos, red or white lead, etc., are water-proof if made thick enough. These are much used for steam joints. Flaxseed meal made into a paste with water is often serviceable, the oil contained serving as a binder as the water evaporates.

2. *Oil-Proof.*—The most useful lute for small leaks, etc., is the well-known "hektograph composition," as follows:

Good glue or gelatin	2 parts
Glycerin	1 part
Water.	7 parts

This is applied warm and stiffens quickly on cooling. Another very useful composition is a stiff paste of molasses and flour. Another preparation, impervious to oil vapors, is the "flaxseed poultice," mentioned in Section 1, which is proof to oil vapors. One of the strongest cements, and one which is really oil-proof, water-proof, acid-proof, and proof to almost everything, is a stiff paste of glycerin and litharge. These form a chemical combination and set in a few minutes. If a little water is added, it sets more slowly, which is often an advantage. It is mixed when required for use. Plaster-of-paris wetted, by itself, or mixed with asbestos, straw, hair, etc., is useful. A solution of silicate of soda made into a stiff paste with carbonate of lime, gets hard in six to eight hours.

3. *Acid-Proof.*—The asphalt compositions already mentioned, compositions of melted sulphur with fillers of stone powder, cement, sand, etc.; also the following, which withstands hydrochloric acid vapors:

Rosin	1 part
Sulphur	1 part
Fire clay	2 parts

The lute composed of boiled linseed oil and fire-clay acts well with most acid vapors. The composition of glycerin and litharge referred to is useful in this connection, especially when made up according to the following formula:

Litharge	80 pounds
Red lead	8 pounds
"Flock" asbestos	10 pounds

fed into a mixer, a little at a time, with small quantities of

* Abstract of paper presented by Mr. S. S. Sadtler before the Engineers' Club, June 4, 1904.

boiled oil (about six quarts of oil being used). Sockets joined in 3-inch pipes carrying nitric acid were calked with this and showed no leaks in nine months. A particularly useful cement for withstanding acid vapors, being also tough and elastic, is:

Crude rubber, cut fine	1 part
Linseed oil, boiled	4 parts
Fire-clay	6 parts

The rubber is dissolved in carbon disulphide to the consistency of molasses and then mixed with the oil. Other examples of acid-proof cements, taken from "A Handbook of Chemical Engineering," by George E. Davis, and vouched for by the author, who has used them in chemical engineering work, are as follows:

"Black putty," made by intimately mixing equal portions of china-clay, gas-tar, and linseed oil. The china-clay must be well dried by putting over a boiler, etc. Barytes cement is composed of pure, finely ground sulphate of barium, and is made into a putty with a solution of silicate of soda. This sets very hard when moderately heated, and is then proof against acids. The gravity of the silicate of soda should be between 1.2 and 1.4, 24 deg. to 42 deg. Beaumé. If too thin, it does not hold; and when thicker than 1.4, it expands and breaks.

4. *Hydrocarbon gases.*—Compositions of plaster and cement, the former setting more quickly, are used. Also compositions of casein, such as:

Finely powdered casein	2 parts
Fresh slaked lime	50 parts
Fine sand	50 parts

Water is added, when used, to form a thick mush. Various mixtures of silicate of soda are employed in which the thick silicate is absorbed in some inert material, as clay, sand or asbestos.

5. *Chlorine.*—The best and only reliable compositions are a few made with Portland cement, and the following is much used for electrolytic and chemical plants:

Powdered glass	1 part
Portland cement	1 part
Silicate of soda	1 part

A small amount of powdered slate.

This lute is said to stand acid and alkali, as well as the influences of chlorine. Linseed oil made into a paste with fire-clay serves for a time.

6. *Elastic Cements.*—The various cements containing rubber are elastic, if it is in predominating amount; many containing boiled linseed oil and the hektograph composition already mentioned are quite elastic. The rubber-linseed oil cement, given under Section 3, is very tough and useful for nearly all purposes except when oil vapors are to be confined. The most useful single rubber lute is probably the so-called Hart's india-rubber cement. Equal parts of raw linseed oil and pure masticated rubber are digested together by heating and this mixture made into a stiff putty with fine "paper stock" asbestos. It is more convenient, however, to dissolve the rubber, first in carbon disulphide, and after mixing the oil with it, to let the solvent evaporate spontaneously.

7. *General Purposes.*—One of the most useful is plaster-of-paris, and especially when mixed with asbestos, straw, flush trimmings, hair, broken stone, etc., used according to temperature, strain, and other conditions. A putty of flour and molasses is a good composition to keep in a works ready for quick application when needed. It serves almost any purpose at moderate temperatures for a time. Casein compositions have great strength. White of egg made into a paste with slaked lime is strong and efficient, but must be used promptly on account of its quick setting qualities.

8. *Marine Glue.*—This can be purchased almost as cheaply as made. The rubber must first be dissolved in carbon disulphide or turpentine before mixing with the heated combination of the other two ingredients. Its uses are well known.

Crude rubber	1 part
Shellac	2 parts
Pitch	3 parts

9. *Gasket Compositions.*—Of course, almost any cementing substance may be used with rings of asbestos, etc., for gaskets, but some are specially adapted to the purpose. With regard to asphalt, tar, pitch and petroleum residuum, soft or hard pitch is recommended, as may be desired, because there are no light oils or water to go off at low heats, and the free carbon and compounds very high in carbon are good fillers to asbestos gaskets at high temperatures. Silicate of soda by itself is much used, but is sometimes advantageously mixed with casein, fine sand, clay, asbestos, carbonate of lime, caustic lime, magnesia, oxides of heavy metals, such as lead, zinc, and iron, and powdered barytes. A few that might be selected are—silicate of soda and asbestos; silicate of soda, asbestos and slaked lime; silicate of soda and fine sand; silicate of soda and fire-clay.

10. *Machinists' Cements.*—These are the well-known red and white leads. The red lead is often diluted with an equal bulk of silica or other inert substance so as to make it less powdery. The best way to do this, however, is to add rubber or gutta-percha to the oil as follows:

Linseed oil	6 parts by weight
Rubber or gutta-percha	1 part by weight

The rubber or gutta-percha is dissolved in sufficient carbon disulphide to give it the consistency of molasses, mixed with the oil, and left exposed to the air for about twenty-four hours. The red lead is then mixed to a putty. Oxide of iron makes a less brittle cement than red lead. Probably fish oils and red lead would make good lutes of the class for joining pipes, as the fish oils are not such strong drying oils as linseed, and their use might be a case of permissible substitution rather than adulteration.

11. *Leather Cements.*—1. Equal parts of good hide glue and American isinglass, softened in water for ten hours and then boiled with pure tannin until the whole mass is sticky. The surface of the joint should be roughened and the cement applied hot. 2. One pound of finely shredded gutta-percha digested over a water-bath with 10 pounds of benzol, until dissolved, and 12 pounds of linseed oil varnish stirred in. 3. Seven and one-half pounds of finely shredded india-rubber are completely dissolved in 10 pounds of carbon disulphide by treating while hot, 1 pound of shellac and 1 pound of turpentine are added, and the hot solution heated until the two latter ingredients are also dissolved. Another leather cement is as follows:

Gutta-percha	8 ounces
Pitch	1 ounce
Shellac	1 ounce
Sweet oil	1 ounce

These are melted together.

Still another is as follows: Fish glue is soaked in water twenty-four hours, allowed to drain for a like period, boiled well and a previously melted mixture of 2 ounces of rosin and ½ ounce of boiled oil is added to every 2 pounds of glue solution.

12. *Iron and stone cements.*—When iron in a fine state of divisions, as in fresh filings or cast-iron borings that have been powdered, is mixed with an oxidizing agent, such as manganese dioxide or a substance electro-negative to iron, such as sulphur, in a good conducting solution like salt or sal-ammoniac, galvanic action sets in very rapidly, and the iron swells, by forming iron oxide, and cements the mass together. It is best diluted with Portland cement:

Iron filings	40 parts
Manganese dioxide, or flowers of sulp'r	10 parts
Sal-ammoniac	1 part
Portland cement	20 to 40 parts
Water to form a paste.	

A hard stone-like composition is made as follows:

Zinc oxide	2 parts
Zinc chloride	1 part
Water to make a paste.	

Magnesium oxide and chloride may also be used in like proportions. When used in considerable quantity this cement is mixed with powdered stone, for economical reasons, the proportions depending upon the character of the work.

* * *

In the new *Times* building there will be few brass railings, signs, etc., requiring polishing. The management estimates that the labor wasted on one brass railing in the old *Times* building would have paid for it in solid silver.

TO MEASURE THE RADII OF DEEP-HOLE DRILLS.

OTTO ECKELT.

Deep-hole drills of the type shown in Fig. 4 should be made so that the cutting edge or lip *a* of the drill shall be a radial

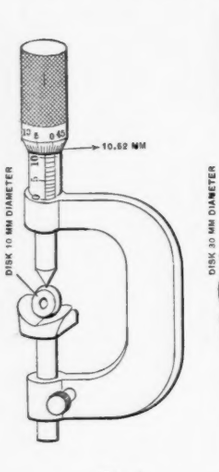


Fig. 1.

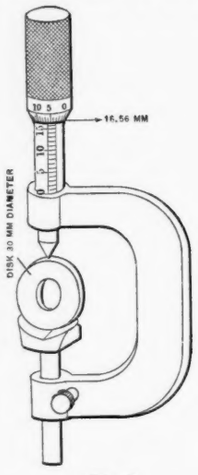


Fig. 2.

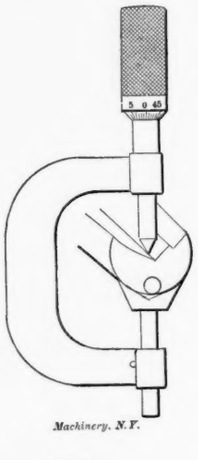


Fig. 3.

line, or in other words, shall go exactly through the center of the drill. It is clear that if a drill is made whose cutting edge lies under the center, a small core of the stock in the center will not be cut off, and will instead tend to remain and form a slender column or thread remaining in the hole. On the other hand if the cutting edge lies over the center, the center portion cannot be cut out, but will be crushed together, the same as occurs with an ordinary twist drill. In deep-hole drilling this will not do as it will very soon cause inaccuracy of the hole or breaking of the drill. Hence it follows that the location of the center exactly in the cutting edge is very important. A glance at a cross section of the drill, Fig. 4, convinces us that a direct measuring of the drill center cannot be made with ordinary instruments. Hence Ludwig Loewe & Co., of Berlin, employ for this purpose a special micrometer with disks and V-shaped anvil block, the principle and use of which is described in the following:

Fig. 1 shows the special micrometer, which measures the radii of deep-hole drills up to 60 mm. (2.338 inches). Its construction is the same as that of an ordinary micrometer with a V-point for measuring screw threads, but in addition it has an adjustable V-block which is locked in position by a clamping screw; also two disks 10 and 30 mm. in diameter are provided. The smaller disk is used for setting the micrometer for drills up to 32 mm., as shown in Fig. 1, and the larger one for drills of 30 to 60 mm. diameter. For measuring drills of small diameter up to 32 mm. the scale of the micrometer is set to 10.52 mm. ($5 + 5 \times 1.1045$) and the disk of 10 mm. diameter is placed in the V-block, which latter is pushed against the measuring point and clamped fast in this position, whereupon the preliminary adjustment necessary is completed. For adjusting the micrometer for drills of 30 to 60 mm. diameter, the 30 mm. disk is used in the same manner, but the scale of the micrometer in this case is adjusted to 16.56 mm. (15×1.1045). After having found the preliminary adjustment of the V-block for drills up to 32 mm. diameter, as shown in Fig. 1, the radius or half the diameter of the drill to be measured is multiplied by the constant 1.1045, and the scale of the micrometer adjusted accordingly; or for greater convenience we may use the diagram, Fig. 9, in which we can read off the product of $r \times 1.1045$ without calculation. For example, suppose we wish to measure a drill whose radius is 7.45 mm. We must find the proper reading for the micrometer screw when the drill is laid in the angle block and the point adjusted, as indicated in Fig. 3. Turning to the diagram, Fig. 9, we find in the upper horizontal scale the figure corresponding to 7.45 and trace downward along the vertical line until we reach the diagonal, thence going horizontally from this point toward the right or left, whichever may be convenient, we find in the vertical scale the number 8.2 mm., or the product of 7.45×1.1045. Hence, if in measuring the drill of 7.45 mm. radius, we get a micrometer reading of 8.2 mm., it is known that the angle of the groove lies exactly in the center of the drill.

To adjust the micrometer for drills from 30 to 60 mm. diameter, the radius of the drill is multiplied by the constant 1.1045 and 15 mm. is subtracted from the product, or $r \times 1.1045 - 15$ mm. = micrometer setting. The diagram, Fig.

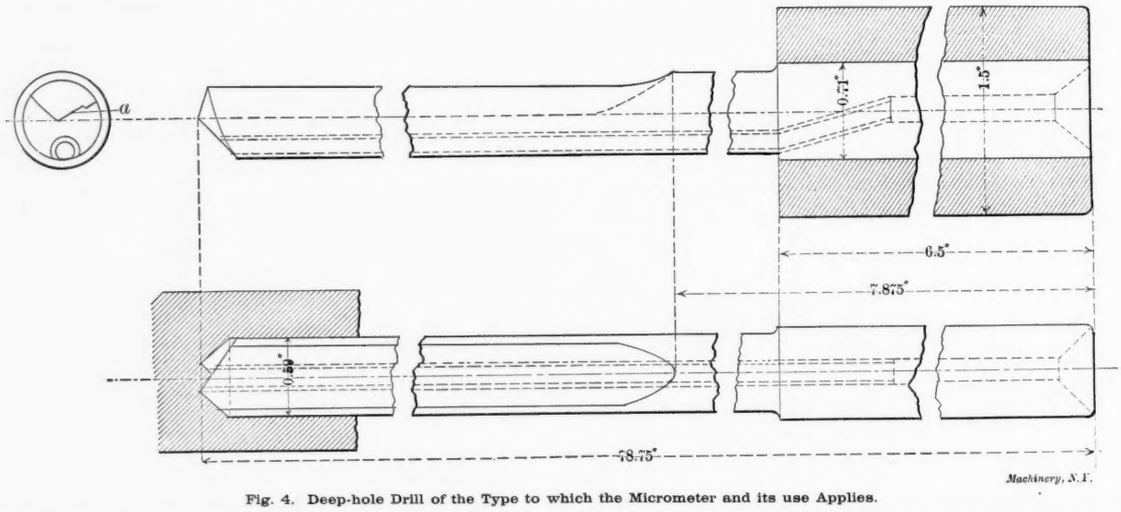


Fig. 4. Deep-hole Drill of the Type to which the Micrometer and its use Applies.

10, however, saves this calculation and is used in the same manner as Fig. 9. For example, to find the micrometer setting for a drill having a radius of 27.35 mm.: In the proper hori-

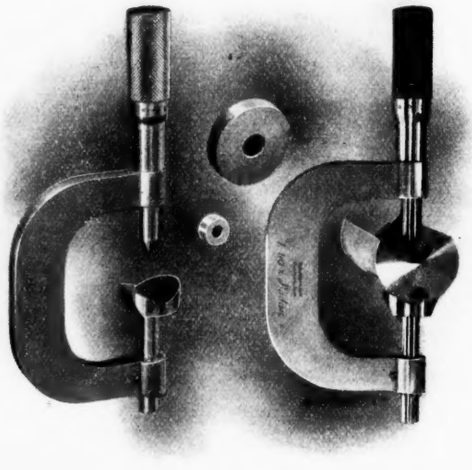


Fig. 5.

Fig. 6.

zontal scale we find the point corresponding to 27.35 and follow the vertical line downward until it intersects the diagonal, thence to the right or left to the vertical where we read 15.2. With this datum any excess or deficiency of thickness

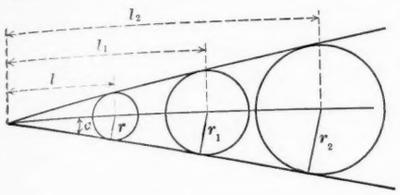


Fig. 7.

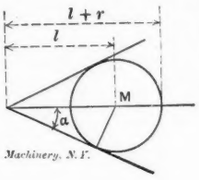


Fig. 8.

of the drill over the center can be read off directly from the scale. Figs. 5 and 6 are from photographs showing substantially the same as Figs. 1, 2, and 3.

Principle of the Gage.

The principle of the gage depends upon the proposition that the homologous sides of similar triangles are in direct proportion. Hence in Fig. 7 we have $\frac{r}{l} = \frac{r_1}{l_1} = \frac{r_2}{l_2}$, etc. Therefore the values of l_1 and l_2 are easy to determine, since $l = \frac{r}{\sin \alpha}$

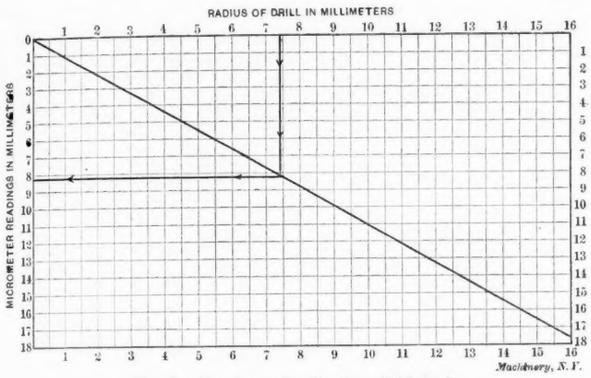


Fig. 9. About one-fourth size of Original.

in which r corresponds to the radius of the drill, and $\alpha = \frac{1}{2}$ the constant angle of the V-block of the micrometer, whence we derive the constant 1.1045.*

It will be observed that the product of the radius by the constant is used directly when setting for drills 32 mm. or less diameter, but that when measuring drills of 30 to 60 mm. the product is diminished by 15 mm. This comes about because in setting to the 30 mm. disk the micrometer screw is adjusted to 16.56 mm (instead of 31.56 mm.) in order to make the

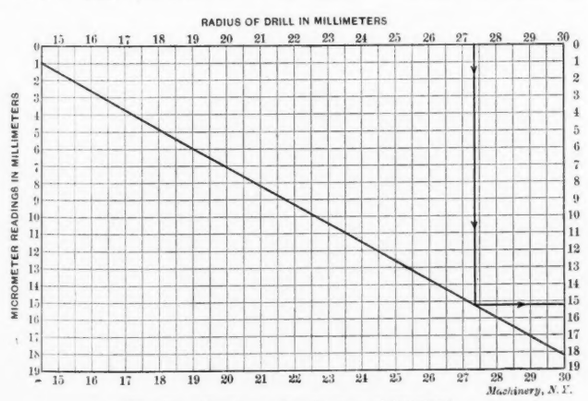


Fig. 10. About one-fourth size of Original.

scope of the micrometer include the larger drills without the need of making a larger frame bow. The principle is illustrated in Fig. 8. For the disk M we reckon $l + r = \frac{r}{\sin \alpha} + r$. Hence if one sets the screw of the micrometer to this measure and pushes the V-block with the disk M resting in it, until the disk is found to be in perceptible contact with the measuring point of the screw and there clamps it fast, the gage is adjusted. The proof of the correctness of the setting is that if we put back the micrometer screw equal to $l + r$ then will the point of the screw lie in the vertex of the angle α. In other words the lengths l, l_1 and l_2 should be exactly indicated without calculation.

* * *

GETTING THE FULL VALUE OUT OF JIGS.

J. F. MIRRIELEES.

At the beginning of this article the writer finds it necessary to make three assumptions: First: That every shop manager recognizes the indispensability of jigs where rapid production at the lowest possible cost, and duplicate workmanship are the aims. Second: That his equipment of jigs be more or less complete. Third: That his jigs be in a somewhat satisfactory working condition.

Throughout this article the word "jig" will be meant to include all jigs, templets, fixtures, appliances, etc., which aid in the rapid and accurate machining of parts. With such assumptions allowed, the necessity for some systematic scheme of management for the use and care of the jigs should be apparent. However, it is not uncommon, even in these days, when the jig is admittedly one of the main factors instrumental in developing the shops of the past (where machinery was "built)," into the shops of the present (where it is "manufactured)," to find concerns where the jigs are given no consideration beyond designing them and keeping them in a questionable state of repair.

The whole tool or jig scheme is so interwoven with the entire shop that the success of a system cannot be dependent entirely upon any one person but upon the co-operation of all.

The tool foreman is the one, after the management, who contributes most to either success or failure, and therefore his selection should be made with care. This tool foreman, as we prefer to call him, is to the modern shop what the head toolmaker was to the old-time shop, and his increased duties and responsibilities entitle him to the new title. He should possess executive as well as mechanical ability, and be broad-minded and up-to-date, for to him should be intrusted the tooling of the machines, the manufacture and care of the jigs, the complete control of the tool room and the enforcement of any system the management may inaugurate. He will, however, be doomed to only partial success, if not absolute failure, without the support of some working system; and that is what this article proposes to outline.

The first thing we find it necessary to provide for is that the separate parts be produced in the most economical quantities. From the fact that the parts are produced rapidly by the use of jigs, in many instances the quantity production is overdone, and the money thus tied up in overstock more than offsets that saved by producing in large quantities. This is a point not appreciated by the average foreman, and, indeed, the superintendent himself may have only an indistinct idea of where that point lies beyond which, if he goes, he is putting an extra expense upon the firm. It is evident, therefore, that this is not a matter to be left to chance, but should be taken up and gone through with by some intelligent person who has a thorough knowledge of the shop conditions, and who has above all an accurate cost record of each piece to guide him. The product of his labor should be a list similar to the one shown in Fig. 1 and which is called a "Production Sheet." From this no deviation should be allowed in the number of parts to be produced at a time, until conditions change, necessitating an increase or decrease in the amounts.

Here I wish to make a point of the difference between "lot production" and "quantity production." In lot production, if twelve machines are to be gotten out, there will be made just twelve of the main parts, and perhaps twice that number of details. The only point taken into consideration is to have

* From the direction to use the constant 1.1045 it would appear that the included angle of the V-block must be 129 deg. 46 min.; the constant stamped on the frame of the micrometer shown in Figs. 5 and 6 is 1.103, but both give an odd figure for the included angle, the latter making it 129 deg. 50 min. In view of the fact that an odd angle was chosen it would have seemed more in the interest of convenience to have made it one that would have given a simpler constant. For instance angle 130 deg. 46 min. would give a constant almost exactly 1.1. —EDITOR.

MR. J. F. MIRRIELEES was born December 19, 1874, at Cincinnati, O. He received his technical education in the Technical School of Cincinnati, and the Ohio Mechanics Institute. His knowledge of the practical side of manufacturing was gained with the R. K. LeBlond Machine Tool Co. Besides this concern, he has worked for W. P. Callahan & Co., and has done special work for various concerns, with which he has held the positions of draftsman, designer, assistant superintendent, and superintendent.

PRODUCTION SHEET

W.P. CALLAHAN & CO. DAYTON, OHIO. U.S.A.

PARTS	AMT.	No.	D	E	F	G	H	I
SUB BASE	1	1	AS ORDERED					
BED	1	2	12	12	12	6	6	3
PILLOW BLOCK CAP	2	3	48	48	48	24	24	12
CYLINDER	1	4	12	12	12	6	6	3
" HEAD	1	5	15	15	15	8	8	5
" RING	1	7	25	25	25	15	15	10
FLY WHEEL	2	8	24	24	24	12	12	6
PULLEY	1	9	25	25	25	15	15	10
CRANK GEAR	1	10	50	50	50	25	25	15
LOOSE "	1	11	50	100	——	50	——	25
PISTON	1	12	12	12	12	6	6	3
" RINGS	3	13	100	100	100	50	50	25
SHAFT CAP	2	14	100	100	100	50	50	24
CHEST BRACKET	1	15	25	25	25	12	12	6
" " CAP	2	16	50	50	50	24	24	12
LOOSE GEAR BRACKET	1	17	50	50	50	24	24	12
CHEST	1	19	25	50	——	25	——	12

PARTS	AMT.	No.	D	E	F	G	H	I
IGNITER POINT LONG	1	246	500	——	——	——	——	——
" " SHORT	1	247	500	——	——	——	——	——
LOOSE GEAR TRIGGER	1	100-A	100	——	100	——	100	——
" " SPRING	2	137	500	——	500	——	500	——
" " " SCR.	1	71-A	500	——	500	——	——	——
" " CAP	1	100	100	——	100	——	50	——
" " OIL CUP	1	249	100	——	100	——	50	——
GOV. TUBE	1	88	50	50	50	50	50	50
" " NUT	1	67	200	——	——	——	100	——
" ROD	1	98	50	50	50	50	50	50
" REGU. SCREW	1	105	100	——	100	——	50	——
" " SPRING	1	145	500	——	500	——	500	——
" BALL SCREWS	2	134	1000	——	——	——	500	——
" GEAR KEY	1	128	1000	——	——	——	——	——
PILLOW BLOCK STUD	4	130	400	——	400	——	200	——
OILER POST	1	117	50	50	50	25	25	12
" CHAIN	2	BUY THESE						

Fig. 1.

enough and no more to complete the lot; while in quantity production there are four points: First, number used in any given period; second, total cost to produce; third, cost to carry, and fourth, proportion of actual machine time to total time. By considering these points we find that we arrive at entirely different results in the two methods.

Suitable methods should prevail in the tool room, or better, in the jig room, whereby a workman when delivered a jig gets all the necessary tools to perform all the operations upon the piece that the jig is designed to do. It should not be necessary for him to ask for the tools separately, but simply to ask for the jig and tools for such or such an operation, designated either by name or number—preferably by number—and have them delivered to him complete. By doing this, much time will be saved, and mistakes will often be avoided. This can be accomplished by giving each jig, all the loose pieces belonging to the jig and all the special tools, the same number as the piece they are used upon. They should be indexed under this number and kept in suitably grouped compartments and the compartments conspicuously numbered so that they can be easily located. In these compartments is also kept a list, Fig. 2, showing what constitutes a complete set. When a jig is called for, reference is made to the index, if necessary, the compartment found and the complete set of jig and tools delivered with reference to the list, Fig. 2.

DRILLING JIG SET-F 42 C.
1 JIG
1 " LID
4 THUMB NUTS
2 SET SCREWS
5 BUSHES
TWIST DRILLS - 31/32" - 3/4" - 17/32" - 1/8"
TAP - 5/8" - 10 THREAD MACHINE
REAMER 1" MACHINE
" TAPER - SPECIAL NO. F 39

Fig. 2.

Probably 50 per cent of all jigs are designed to perform two or more operations; and when such is the case, to economize in time and often to obtain the best results in machining, each jig should have its operation sheet, Fig. 3. To illustrate why it is necessary to perform the several operations in a prearranged order: Take for instance two holes intersecting at acute angles, such as a shaft hole and a locking rod hole, where the locking rod hole drills half out into the shaft hole. Ordinarily a workman would drill the larger or shaft hole first, and the locking rod hole afterward. This would be wrong, however, for the locking rod hole drill upon entering the shaft hole and meeting no resistance for half its diameter, would run out and the hole would not be straight.

DRILLING OPERATION SHEET F 42 C.
DRILL 31/32"
REAM 1"
REVERSE LID AND
DRILL 17/32"
TAP 5/8" - 10 THREADS
DRILL 3/4"
" 1/2"
REAM 1/8" SPEC. NO. F 39
NOTE:- CARE MUST BE TAKEN THAT CHIPS DO
NOT ACCUMULATE IN CORNERS OF JIG.
NOTE:- DO NOT TIGHTEN TOO MUCH ON SET
SCREWS AS THERE IS DANGER OF SPRINGING
WORK.

Fig. 3.

A very handy arrangement is to have the tool sheet, Fig. 2, and the operation sheet, Fig. 3, mounted upon opposite sides of a cardboard. They should be of some convenient size, to be determined by the number of separate items it is necessary to put upon them.

It is regretfully too generally the custom to take for granted that a piece is right if it has been jigged, and in this way much work is often spoiled that could be avoided by the simple system of inspecting the first piece of every lot done in a jig and ascertaining its correctness. If the first piece is found to be correct it is reasonably safe to assume that the rest will be. It will be well to provide printed blanks upon which defects and possible improvements in jigs are reported to the tool foreman. These are made out in duplicate by the foreman under whom the defects, etc., are discovered, he keeping the copy and sending the original to the tool room. This method will be found to be superior to giving verbal instructions, as it is a check from one foreman to another. There is an adage which cannot be more appropriately applied than in the case of repairing jigs and keeping tools up, and that is, "don't put off until to-morrow what can be done to-day."

It seems hardly necessary to mention the matter of allowing repairs to be made upon jigs in any other place than the tool room, because it is so obviously wrong that every one must see the fallacy of such a course and what a demoralized state of affairs it will lead to; yet in some shops, where if one were to insinuate such a thing to the management they would throw up their hands in horror, I have seen a man "just taking off the wire edge," or "just easing it up a bit." In this matter there should be absolutely no margin, and it should be considered a misdemeanor, punishable with immediate dismissal, for a workman to assume any part of the tool room duties, however trivial.

If the first thing has been done toward improving the conditions and establishing a system, and that first thing is a competent tool foreman, such matters may safely be intrusted to him, for if he is held responsible for the jigs he will assuredly not tolerate such methods.

* * *

The recently-completed office building of the B. F. Sturtevant Co., Hyde Park, Mass., has four stories and a basement and is of handsome, yet simple design. The interior is finished in oak, while the decorations and fixtures are tasteful and appropriate. The building is heated and ventilated by the Sturtevant fan system, the heated fresh air being conveyed to the rooms through galvanized iron flues built into the walls. The heating and ventilating apparatus is in the basement, where are also the printing plant, and a lunch room for the office employees. The two lower floors are taken up by the business offices, the third floor by the drafting rooms, and the fourth floor is at present used only for the blueprint department. Eight large fireproof vaults give abundant room for the safe-keeping of drawings and other valuable data.

TOOL MAKING.—14.

MILLING MACHINE CUTTERS (Continued).

E. R. MARKHAM.

Side Milling Cutters.

Side milling cutters, Fig. 19, are used for cutting the sides or ends of work, as shown in Fig. 20; also for cutting grooves, as, having teeth on the end, the friction is much less. When cutting the teeth on the end, the mill is held on a solid stud in the chuck on nose of spindle of centerhead; or on a plug which fits the tapered hole in the end of the spindle. The stud may be solid, or the end that enters in cutter hole may be made as in Fig. 21, which shows an expanding plug. The end of the mill being cut must not be set parallel with the milling machine table or the top of the tooth will not be of an equal width its entire length. The amount of angularity must be determined by experiment.

The angular cutter for producing the teeth on the end of the mill must be selected with reference to the use to which the cutter is to be put. For general use, a mill that will produce a tooth having an angle of about 60 degrees to the face of tooth answers nicely.

If greater strength is required a cutter that will form a tooth having an angle of 70 degrees may be used.

When cutters of unequal sizes are used together, as in Fig. 22, it is advisable to let the smaller into the larger as represented. If this is not done the teeth at the end of the smaller cutter, where it adjoins the larger, will break away leaving a fin on the work. When cutters of the same, or nearly the same diameter are used, various methods are employed to prevent this result. The more common method consists in making them with interlocking teeth or as it is sometimes

Fig. 19

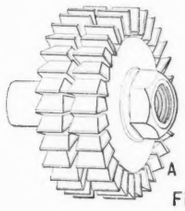


Fig. 23

Machinery, N. Y.

termed, "dodged" teeth. In some shops every other tooth is cut away; the corresponding tooth on the other being left, projects into the recess. In other shops two, three, or even more teeth are cut away, and then a corresponding number left. These two forms are shown in Fig. 23 at *A* and *B*. For cutting these teeth away the cutter is placed on a solid or on an expanding plug, as when cutting the teeth on the end of a side milling cutter, and a mill of the proper width having a flat face is run through; or a narrow mill is used and the index head revolved to give the desired result. In this form of milling cutter the groove between the projecting teeth should be cut deep enough so that the teeth entering them will not bottom. The cutters should bear against each other on their hubs, as shown in Fig. 24.

A very satisfactory form of slotting cutter, where it is necessary to get adjustment as to width, may be made as in Fig. 25, and in many shops this form has superseded the cutter with interlocking teeth for the purpose mentioned. To make this form of cutter use an eccentric mandrel like that in Fig. 26. This mandrel has two sets of centers; the eccentric centers are located equidistant from the regular centers but on opposite sides, on the opposite ends, as shown. Half of the cutter is placed on the mandrel so the end that is to be cut at an angle shall be half-way between the ends of the mandrel, as shown in Fig. 27. After facing the end *a* by running the mandrel on the concentric centers, the eccentric centers are placed on the lathe centers and the end *b* is faced as shown. The two parts are then put together on a stud and the hole drilled and reamed for the dowel pin, *a*, Fig. 28. The cutter is then placed in the vise of the shaper or planer and the keyway cut, after which the teeth are milled. The necessary adjustment for width of the slot is obtained by blocking apart by means of collars of tin, thin sheet steel, or paper.

When a milling machine cutter is employed cutting a wide, flat surface the chip removed by each tooth is apt to have a length corresponding with the length of the portion of tooth cutting. Removing this long chip brings considerable strain on the cutter and requires a greater amount of power than taking a number of short chips aggregating in length that of the long chip. To accomplish this the surface of cutter teeth is sometimes broken by means of cuts, as in Fig. 29. This process is termed "nicking," and cutters so treated are termed cutters with nicked teeth. Such cutters are specially adapted for milling wide surfaces when heavy cuts are taken. It is

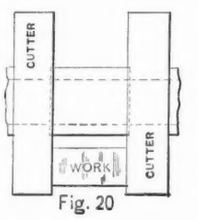


Fig. 20

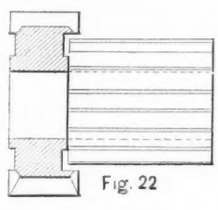


Fig. 22

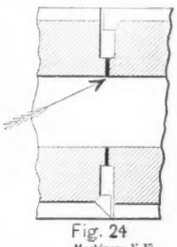


Fig. 24

Machinery, N. Y.

apparent that the location of the nicks on one tooth must not be in line with those on the adjoining teeth. The nicking may be done as follows: An engine lathe may be geared to cut a thread of the desired pitch—two threads to the inch answers nicely—and a round-nose tool ⅛ inch in width, or a tool similar to a square-thread tool having its corners rounded, may be used to cut the thread. If the latter form of tool is used it must necessarily be thin as we do not wish to cut a wide groove, the desired object being to break the chip. The thickness given for the round nose would answer for the latter form.

The cut should be sufficiently deep to prevent its being ground out, before the tooth has been ground as much as possible before reworking. The thread should be cut before the teeth are milled.

Form Mills.

Cutters of irregular shape whose teeth are not backed off with a forming tool, and which are *not* ground on their faces when sharpening, are in many shops termed "form mills." Such a cutter is shown at *A* and *B*, Fig. 30. If but one mill is to be made the shape is generally produced by blocking out somewhere near to shape with the ordinary lathe tools, then finishing to shape with hand tools. If several cutters of the same design are required a forming tool will be needed. If the necessary facilities are at hand it is made of the form shown in Fig. 31. This is known as a *formed* mill and may be ground on the faces of the teeth without altering their shape. The teeth of cutters of this class should be very

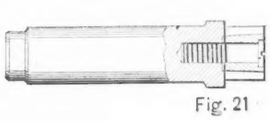


Fig. 21

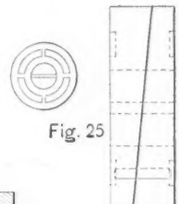


Fig. 25

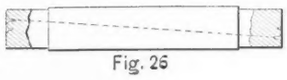


Fig. 26

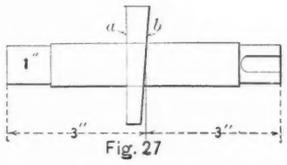


Fig. 27

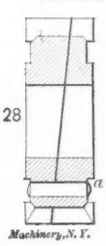


Fig. 28

Machinery, N. Y.

coarse; frequently, a 3-inch mill will not have more than seven teeth. These can be made more cheaply in shops provided with machinery adapted for this class of work, but very few manufacturers make formed mills in quantities sufficient to warrant the purchase of a machine, which could be used for no other purpose. As a consequence some of the manufacturers of engine lathes make an attachment that can be applied to their lathes, and which answers the purpose nearly as well as a machine made purposely for this work,

unless extremely long mills are to be operated on, or those which subject the machine to great strains.

In the absence of a special machine, or of an attachment, an ordinary engine lathe may be rigged up for this purpose, provided there is one in the shop sufficiently heavy and rigid. It is a serious mistake to take some *old* lathe, so badly worn as to be of little use for any purpose and attempt to convert it into a backing-off lathe, as it will not give satisfactory results. It is cheaper, generally speaking, to get new machinery than to attempt to patch up worn-out machines, especially if they are not adapted to the work at hand.

If the cutters are comparatively short an inexpensive backing-off fixture known as Balzar's backing-off device may be

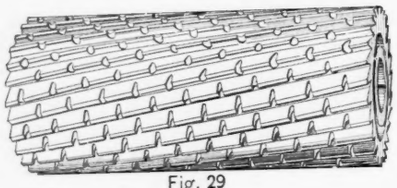


Fig. 29

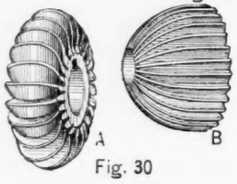


Fig. 30

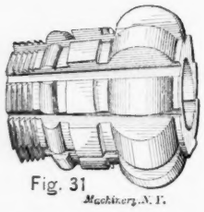


Fig. 31

Machinery, N. Y.

procured, Fig. 32. This fixture is held between the lathe centers. The cutter being operated on is held on an arbor provided with a key which enters the keyway in the cutter. The keyway must be cut with special reference to the location of the teeth in order that the backing-off which is governed by an eccentric may work in reference to the cutting surface of the tooth. The fixture has a ratchet connected with the arbor. This is operated by a pawl. This ratchet wheel contains ordinarily 36 teeth, so it is apparent that cutters containing 6, 9, 12, 18 or 36 teeth may be backed off on it. Although this fixture has been on the market for a number of years it is not as generally known as it deserves to be. It is not only a useful device but it is an application of mechanical principles that is somewhat novel.

Backing Off Cutter Teeth On a Faceplate.—A method in use in some shops and formerly more commonly used than at

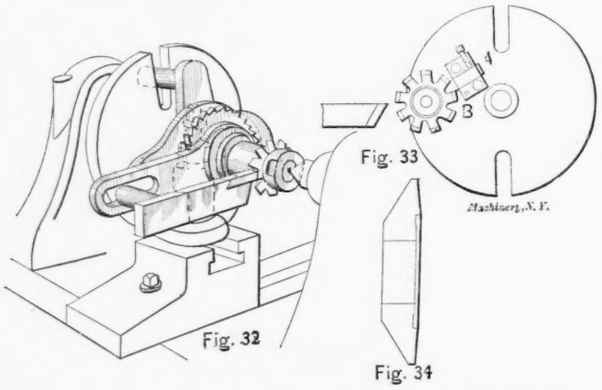


Fig. 32

Fig. 33

Machinery, N. Y.

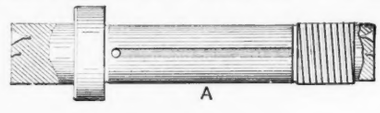
Fig. 34

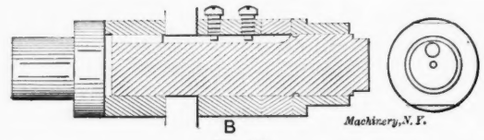
present, consists in placing the cutter on a stud in the faceplate of a lathe, Fig. 33. It is necessary to provide a finger, one end of which fits into the gashes in the face of the cutter. And, by the way, it is also necessary to cut grooves somewhat narrower than the finish grooves are to be across the face of the cutter after it is formed to shape by means of the forming tool. These grooves are cut in formed mills before backing off the teeth. This cut should be made with an angular cutter of the form shown in Fig. 34.

The cutter is located on the faceplate by means of the finger shown but it must be held while being operated on by the nut on the end of the stud. The forming tool is fed in gradually by means of the cross-feed screw, the lathe spindle being revolved sufficiently to cause the tooth to pass the forming tool, when it may be turned back and the tool fed in for the next cut. Each tooth is operated on separately, being fed in until nearly the desired amount of cutting is done. When all the teeth have been cut in this manner the forming tool is sharpened and a light, finishing cut is taken on each tooth. When using this method cut the grooves somewhat wider than when almost any of the other methods are employed. In fact, they must be somewhat wider than the thickness of the teeth. After backing off it is necessary to mill the *faces* of the teeth about 1-32 inch, to remove the portion at the edge of the tooth that is cut a trifle deeper than the portion just back of it. This is caused by the forming tool drawing in when the cut commences.

Eccentric Backing-off Arbor.—A very simple fixture may be made for backing off cutter teeth. It consists of an eccentric arbor operated by a lever attached to one end. This arbor is shown with and without collars and nut, in Fig. 35. The amount of eccentricity must depend on the size of the cutter to be backed off; for those 4 inches diameter and under ¼ inch answers nicely. The spline cut extending nearly the whole length of the straight part of the arbor is to receive ends of the screws which extend through the collars, thus preventing their turning when pressure is applied to the nut used to fasten the cutter securely on the arbor. The screw to receive the nut on the end of the arbor should be of comparatively fine pitch; 12 threads per inch does very well. The cutter being operated on is not fastened by means of spline, or key, as it is necessary to turn the cutter on the arbor each time a tooth is brought into position.

The cutting is done by moving the lever the required amount, and should be set so as to strike the top of the lathe carriage





Machinery, N. Y.

Fig. 35

when at the end of the stroke. To prevent its bruising the carriage of the lathe a strip of leather may be attached to the lower side where it comes in contact with the carriage. When a tooth is brought into position for backing off it should be so located that at the end of the stroke the tooth above it will not come in contact with the forming tool. This is done by lowering the lever so that it rests on the carriage, as shown in Fig. 36, then moving the cutter until the tooth above the one to be backed off rests on a strip of sheet metal placed on top of the forming tool, as shown at *a*. This strip is then removed, the tool withdrawn, the lever elevated, and the tool fed in right for the first cut. It is necessary to remove the tool each time the lever is elevated for return of tooth, and as a consequence a lathe is needed having a cross-feed stop, or a graduated dial on the cross-feed screw. The latter is the more satisfactory.

When using the eccentric arbor observe the same instructions given for using the stud on the faceplate; that is, take the necessary number of cuts on a tooth to bring it nearly to finish before turning to the next tooth.

It is advisable to grind formed mills after hardening and before using. Cutters of this description are ground on the faces of the teeth, and fixtures are used having a guide which properly locates the tooth to be ground by means of a locating finger that gages by the back of the tooth being ground, or against the cutting face of the next tooth, as shown in Fig. 37. Other forms of fixtures have a dial and pin.

Mills should be kept sharp; they dull rapidly when the keen cutting edge is gone, and as there is so broad a face to grind a vast amount of time is consumed if very much stock is to be removed. Then again, the life of the cutter is much shorter under these conditions than if ground when only slightly dull.

Milling Cutters with Inserted Teeth.

Milling cutters exceeding 6 or 8 inches diameter are usually made with inserted teeth; it is cheaper than making of a solid piece of steel, and danger of cracking when hardening is entirely eliminated. If the cutter is narrow, or is to be used for side milling, the grooves to hold the teeth may be straight—at right angles to the end; if the cutter is over 1 inch long make it with teeth that are spiral in form.

As it would not be practicable to make the blades of a shape to fit a spiral slot in the body of the cutter the slots are generally made at an angle to the ends. The blades are made straight, placed in the slots, turned to the required size and

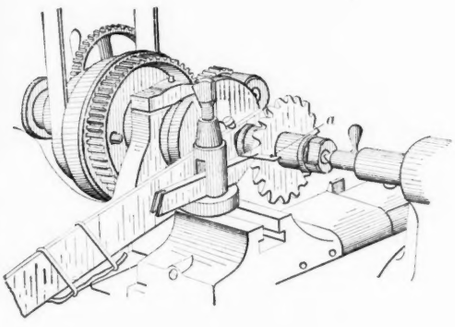


Fig. 36.

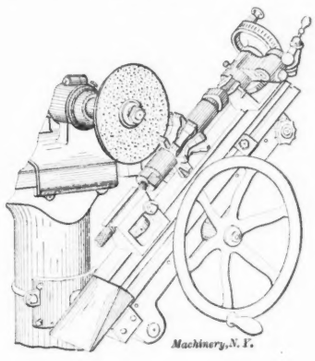


Fig. 37.

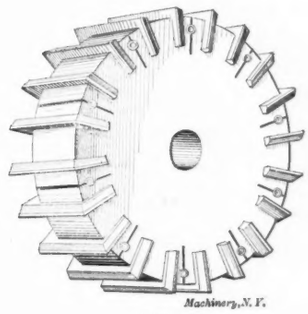


Fig. 38

then the portion above the body is milled spiraling. If the cut taken with the mill is long or heavy the teeth are nicked, as described in section under nicked teeth.

If the grooves that are to receive the blades are to be milled at an angle to the axis of the cutter they should be equidistant from a radial line at each end of the cut; they will of course be on opposite sides of a line drawn parallel to the axis.

Various methods are employed for holding the blades in place. The method used must be decided by those familiar with the character of the work in the individual shop. Fig. 38 shows that used by the Pratt & Whitney Co., Hartford, Conn. Between every second pair of teeth a hole is drilled. This is reamed with a taper reamer to receive a taper pin. After reaming, the slots are cut with a thin metal slitting saw. When the blades are in position the taper pins are driven into the taper holes, closing the stock onto the blades and securely holding them. To remove the blades drive the taper pins out, and the stock springing back to its normal position leaves the cutter free.

The method used by Brown & Sharpe Mfg. Co., Providence, R. I., is illustrated in Fig. 39, and consists of taper bushings and screws, as shown.

A third method is shown in Fig. 40, and is used by the Morse Twist Drill and Machine Co., New Bedford, Mass. To furnish a means of fastening the blades by this method the

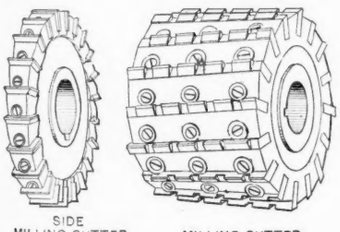


Fig. 39

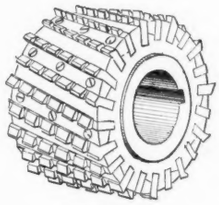


Fig. 40
Machinery, N. Y.

stock between every second pair of teeth is milled away yet not so deep as the grooves for the cutters. Wedge-shaped pieces of steel are fitted between the teeth, as shown. These binding pieces, however, must not reach the bottom of the cuts made for them. They are drawn to place by fillister-head screws.

It is possible when using inserted-blade cutters to have the blades of high speed steel, which makes it possible to use extremely high speeds and coarse feeds, and thus getting a greater amount of work.

While it is customary to use the circumference of the emery wheel when grinding milling machine cutter teeth for clearance, nevertheless this leaves the clearance edge of the tool somewhat concave in shape, and necessarily weak at the portion where the greatest amount of breaking strain comes. If the wheel used is the largest possible the amount of concavity is, of course, much less than when a small wheel is employed. To overcome this difficulty wheels are made of a shape that allows them to be used as shown in Fig. 41. The cutting is done with the end of the wheel and the cutter is held in a fixture that can be tipped to the desired angle when grinding teeth on the end of a side milling cutter, as shown.

While the cut shows the wheel grinding the teeth on the end of the mill, the teeth on the face may be ground by the use of the same form of wheel. This leaves the clearance at the desired angle and the surface straight rather than concave. To some mechanics this may appear to be straining a point, but the writer's experience convinces him that cutters ground so as to leave the clearance surface straight, rather than concave, will stand severe strains and heavy cuts, with less liability of chipping the cutting edges.

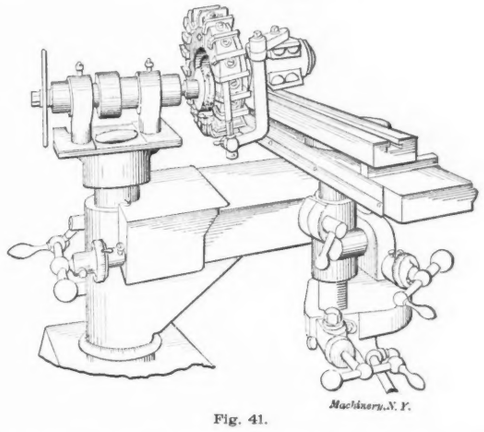


Fig. 41.

While a volume might be written on this subject, it is necessary to conclude, with a few words of caution: Do not make cutter teeth too fine; for many purposes they should be coarser than stated in table in previous article. Do not make them weak; strong teeth may be left much harder than weaker ones; do not overheat cutters when hardening; do not heat them unevenly; do not quench them unevenly in the bath; do not draw temper any more than is necessary; do not draw temper when grinding teeth for clearance; do not use the cutter on an arbor that does not fit the hole in milling machine spindle; do not use on an arbor that does not run true; do not use on an arbor that is smaller than hole in cutter; do not use collars on arbor, if any chips are bedded into their ends, as this would cause the arbor to spring, and the cutter run out.

Do not use a nut on end of arbor, unless the end that bears against collars is true with threads on inside. Do not run the cutter at speeds that will cause it to heat and draw temper; on the other hand run at the maximum speed so as to produce the greatest amount of work possible. Do not fail to give the cutter all the feed it will stand. Do not fail to supply a suffi-

cient quantity of lubricant; this not only keeps the cutter cool, but it washes the chips from between the teeth, thus preventing friction. Do not use dull cutters; keep them sharp. Do not attempt to do a piece of milling on a machine, or in a fixture that is not heavy enough for the job. Lastly, do not fail to keep the milling machine well adjusted.

* * *

THE LINDMARK STEAM TURBINE.

It has been known for some time that the De Laval Steam Turbine Co., Stockholm, Sweden, were developing a compound steam turbine for use where greater power is desired than it has been found advisable to attempt to supply with the single-wheel De Laval turbine. This new turbine is made under the patents of T. G. E. Lindmark, the first of which was issued in this country in 1902. Along substantially the same lines as the Lindmark inventions are patents taken out by P. J. Hedlund and consigned to the same company. At present no information concerning the Lindmark turbine is available other than given in the patent records, but inasmuch as a new principle is involved in the operation of this invention, it will be of interest to explain the features of this turbine in so far as is now possible.

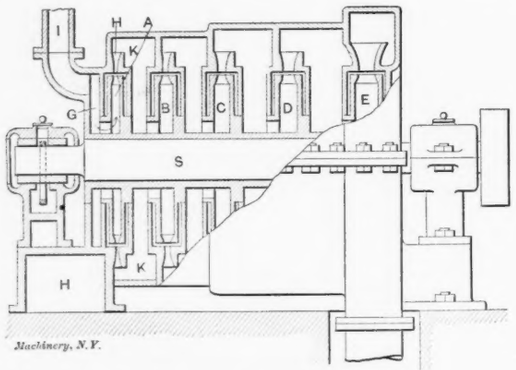


Fig. 1. Section of Lindmark Turbine.

Fig. 1 is a representation of a typical turbine containing the turbine wheels, *A*, *B*, *C*, *D*, and *E*, attached to the shaft, *S*, and rotating with it. Each wheel rotates in a separate compartment and is of the radial outflow type. The steam enters through an inlet pipe, *I*, to the steam space, *G*, whence it flows in the direction of the arrow into the first wheel, *A*. The two sides of the wheel converge at the periphery, forming a contracted outlet, and the steam discharges between curved vanes located in this contracted space, and flows through a diverging annular opening shown at *HH*, which guides the steam into a second compartment at *KK*. This process is repeated in connection with wheels *B*, *C*, *D*, and *E*.

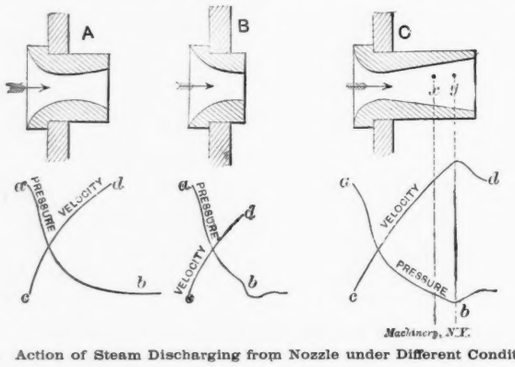


Fig. 2. Action of Steam Discharging from Nozzle under Different Conditions.

Purpose of the Turbine.

The peculiarity of the turbine lies in the pressure and velocity effect upon the steam of the converging and diverging passages as the steam progresses through the turbine. The purpose of the inventor is to transform the potential energy and pressure of the steam into kinetic energy and velocity as it flows through the converging passages of any given wheel, and then to transform the residual kinetic energy and velocity of the steam after it discharges from the wheel into potential energy and pressure during the passage through the annular space, *HH*.

Flow of Steam through Nozzles.

In order to explain the principle whereby this result is accomplished, it will be clearer to first refer to the action of steam in flowing through nozzles of different proportions. In Fig. 2 is shown a converging and diverging nozzle at *A*, through which steam flows from a higher to a lower pressure in the direction of the arrow. The nozzle is supposed to be proportioned so as to give complete expansion, and the pressure will accordingly drop from *a* to *b*, while the velocity will increase from *c* to *d* as indicated by the diagram below the nozzle.

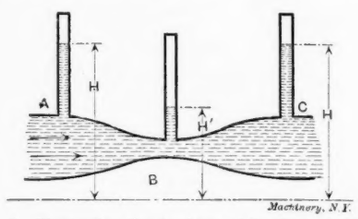


Fig. 3. Illustrating the Analogy of the flow of Water.

At *B* the diverging part of the nozzle is cut away so that the steam does not have the opportunity to fully expand until it has left the nozzle. The pressure, therefore, will gradually drop from *a* to *b*, at which latter point the steam leaves the nozzle and suddenly expands to the lower external pressure, producing a sudden change, *b*, in the curvature of the pressure line. Inasmuch as the expansion is not complete in the nozzle, the velocity line does not rise to as high a point as in the previous case.

At *C* the nozzle is shown lengthened out so as to produce over-expansion; that is to say, when the steam reaches point *x* in the nozzle it is expanded down to the external pressure of the medium into which the nozzle discharges, and beyond this point the steam will expand to a few pounds below the outside pressure until, say, point *y* is reached. After this the pressure will rapidly rise again until it reaches the external pressure at the mouth of the nozzle.

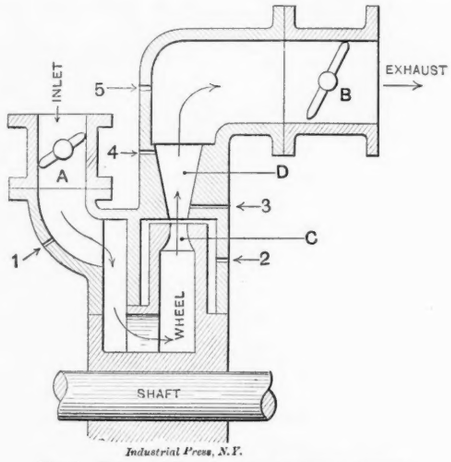


Fig. 4. Enlarged Detail of the Lindmark Turbine.

The Action in the Lindmark Turbine.

It is this latter action which takes place in the diverging passages of the Lindmark turbine. The steam having expanded to a very low pressure appears to follow laws somewhat similar to those governing an inelastic fluid like water, the static pressure and velocity of which change when flowing through a pipe with a varying cross section. Thus, in Fig. 3 is shown a pipe with a contracted section at *B*. Water is flowing in the direction of the arrow and the water rises in the first tube to a height *H* above the datum line. The water must here flow more rapidly in order that the same quantity shall pass through the pipe. This increases its kinetic energy, and consequently must reduce its potential energy, represented by its static pressure, and the water would

stand at a lower level, H', in the tube at this point. At C the flow has decreased again to the original velocity (neglecting friction), and the static pressure is again represented by H.

In like manner, when steam has been expanded to a low pressure and made to flow through a passage of varying section, an increase in the area of the passage will cause a retardation of the velocity of flow, and hence an increase in the pressure; whereas, if the expansion had not been carried to a low pressure, a passage with an increasing area of cross section would cause a decrease in the pressure and an increase in the velocity.

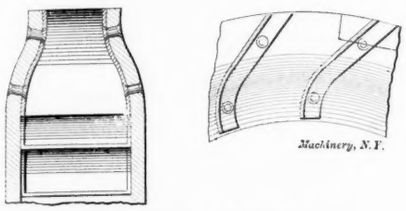


Fig. 5. Vanes of the Turbine.

The application of the principle can still further be explained by referring to the detail sectional sketch of the Lindmark turbine shown in Fig. 4, which represents half of one of the wheels and the connecting passages. Steam enters through the inlet and passes through the wheel in the direction of the arrow, and thence to the exhaust chamber, whence it escapes through the valve, B. Suppose first the turbine wheel to be blocked so that it will not turn, valves A and B to be wide open, and the steam to flow freely through the turbine. At points 1, 2, 3, 4, and 5, are openings to which gages may be attached for determining the pressure at the different points. The steam passages, C and D, will now act like a converging and diverging nozzle. At 1 the entering steam would be at boiler pressure; at 2 the pressure within the wheel casing would be substantially that at the throat of the nozzle, or about 6-10 of the boiler pressure,* at 3 it would be slightly lower; and at 4 nearly as low as the pressure in the exhaust space indicated by the gage at 5.

Action, Wheel Blocked, Exhaust Valve Partially Closed.

Now, suppose valve B to be closed as much as possible without increasing the pressure, 2, within the wheel chamber. The pressure at 1 will obviously remain as before, and the expansion in the passages, C, of the wheel will, as before, carry the pressure at the throat of the nozzle to six-tenths of the initial pressure. After the steam enters the diverging

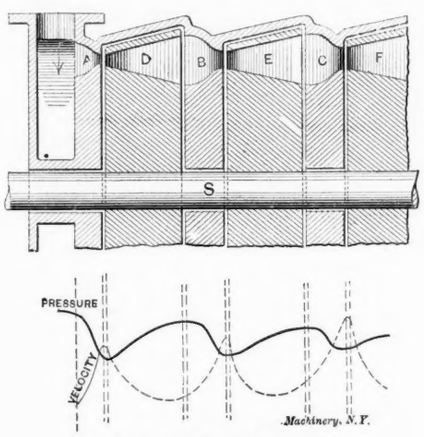


Fig. 6. Hedlund's Invention.

space, D, however, over-expansion will occur just as in nozzle, C, Fig. 2. Probably the lowest pressure will be at or near the point where the gage is attached at 3, and from there on the velocity will decrease and the pressure will increase so that the gages at 4 and 5 will indicate a pressure considerably higher than that in the wheel chamber at 2, but lower than the initial pressure at 1.

* According to the well-known law that the pressure at the throat of a nozzle is 58% of the initial pressure, when the discharge takes place in a space the ambient pressure of which is at least 58% of the the initial pressure.

Action with the Wheel Rotating.

Finally, if the wheel now be supposed to turn, instead of being blocked as before, and the exhaust valve still be partially closed, the principle of the steam's action will remain the same, the only change being due to the altered velocity of the steam owing to the fact that part of the velocity will be absorbed by the vanes of the rotating wheel. Under these conditions the velocity of flow when the steam reaches the entrance to the diverging portion will be less than before and this will produce an effect, which, according to the experiments of Lindmark, will reduce the pressures somewhat at points 4 and 5.

The Lindmark turbine is a reaction turbine, since the expansion of the steam and increase in velocity occur in the passages of the wheel vanes and the curvature given to them is similar to that employed for reaction wheels of other types. See Fig. 5.

Hedlund's Invention.

The Hedlund invention is the complement of the invention of Lindmark, and is designed to cover the same principle in turbine design, but with the converging passages located in the stationary part of the turbine and the diverging passages located in the rotating parts. In Fig. 6, A, B and C are the stationary converging passages, and D, E and F, the diverging passages in the rotating wheels attached to the shaft, S. In flowing through the turbine the passage of the steam fluctuates as shown in the diagram in the lower part of the figure, its general tendency from beginning to end being downward; while the velocity increases and decreases as indicated, but with an upward tendency.

* * *

GAS ENGINE ECONOMY.

GEORGE MILLER.

The question of economy in the consumption of fuel is of great importance to the purchasers of gas or gasoline engines, and incidentally to the manufacturers of those engines, also; for, all things being equal, the firm that builds the most economical engine in the way of fuel consumption, or, in other words, that gives the best results for dollars expended, will get the largest amount of business, and as a corollary thereto, the greatest number of dollars. The question now arises, How shall we get the greatest amount of power out of a given sized engine with a given amount of fuel?

After having spent several years in studying this question and making experiments, and during that time having also built a large number of gas and gasoline engines, the writer of this article is firmly convinced that the position of the igniter in its relation to the charge of gas in the cylinder has far more to do with the economy of gas engines than is generally understood. It is a well-known fact that the charge of gas and air in the cylinder of an engine in operation is more or less stratified; that is, the air and gas are not thoroughly mixed, but portions of the charge are rich and others poor in gas Someone might ask what difference this makes. When the explosion occurs the charge is entirely consumed and the piston receives its impulse from the expanding gases. The answer to this is: "All the difference between high and low economy in the consumption of fuel." If the charge is ignited at a point where it is rich in gas, the explosion is very sharp and strong and gives an injurious shock to the engine. The exhaust also is liable to be smoky, resulting in a loss of power. If the charge is ignited at a point where it is poor in gas the explosion is too weak, resulting also in a loss of power, to overcome which the engine is fed more gas or gasoline, with a consequent loss in economy. This argument is based on the assumption that the engine was at first fed the proper amount of gas and air to give the most efficient service. Now there are one or more parts of the indrawn charge where the air and gas are in exactly the right proportions. If the igniter can be brought in contact with the charge at this part, the result is the greatest economy and efficiency.

It has been said by a prominent writer on gas engines that in designing a gas engine we can never be sure beforehand what the results will be. He says that an engine of given dimensions should develop a certain horse power, but when the engine is built and put in operation the result may be

very disappointing. In other words, the whole science of gas engine building, according to the writer, is a mere matter of guess work. Now I contend that this is wrong,—the science of gas engine building should be as exact as is the science of steam engine building. Imagine a man of to-day experimenting on steam engines in order to find out what size is required to run a certain plant! It is not for one instant claimed that the builders of gas engines have not advanced scientifically and intelligently in the direction of accurate knowledge as to the working of gas engines, nor do I claim that the placing of the igniter in the proper position on the cylinder would put this industry among the exact sciences, but I do claim that it would make a great advance toward that end.

When a charge of gas and air enters the cylinder, it is more or less thoroughly mixed, and the path it takes is governed by the shape and position of the inlet valve and also by the shape of the cored passages, so that the richest part of the charge will vary more or less in position in the same type of engine, giving more or less economy, unless the passages are machined of an exact size or very carefully molded. Competition is too keen nowadays for manufacturers to enter carefully into these details. The chief trouble, however, with most gas engine ignition does not lie in any inaccuracy in the inlet passages, but in the fact that the igniter is put in "any old place." As long as the charge ignites, some manufacturers—and their name is legion—think the engine is all right, not knowing that it is on the proper placing of the igniter that the engine mainly depends for its efficiency and economy. It is this false policy that has brought the gas engine rather into disrepute and lessened its sale. The writer is convinced that if this matter were properly attended to, and the scientific placing of the igniter more thoroughly understood, it would result in a greatly increased sale of gas engines. Some makers claim that the best point of ignition is right in the center of the charge, so as to ignite it in its entirety as rapidly as possible, but, as was said before, this depends upon the richness of the charge at that point. Moreover, the same principle should be applied to gas engines as is applied to guns. A small engine, like an army rifle, should have a sharper and more sudden explosion, and a large engine, like a cannon, should have a slower explosion, corresponding to the slow-burning powder used in large guns. This makes them run smoothly and without shock.

The explosion in the cylinder is of an exceedingly high thermal efficiency, but it lasts only a short time and drops quickly to a very low point. In small engines of high speed a large amount of firing lead should be given, so as to take advantage of this high efficiency at the proper moment and not lose any of the resulting heat units. The explosion and combustion of the charge in this case must be more sudden, hence the igniter should be placed at a point where the charge is slightly richer in gas. The collapse of the explosion and loss in heat units is also very sudden, and unless advantage is taken of these facts there is a great loss of power. As the engines increase in size the explosion and combustion of the charge must be slower, and the point of highest thermal efficiency must be later; otherwise the engine will receive a sudden and severe shock that is very injurious to the working parts. If it is sought to overcome this by giving the engine less lead, the result will be loss of power. Now some manufacturers go ahead blindly and put the igniter in the same relative position on all their engines, irrespective of design or size, with the result that a few run over and a large number run under the expected horse power.

Let me here give an experience that came under my personal notice. A certain shop in Canada had been building gas engines designed by an expert. The igniter was directly on the top of the cylinder, a position which was soon condemned, as it was almost impossible to start the engine in cold weather without first warming the cylinder, since the gasoline vapor, being heavier than air, would not rise to the igniter. It was therefore decided to place the igniter as low down on the side of the cylinder as possible, which as can readily be seen, was an even worse position than the former, for I found by actual test that the consumption of gas was greatly increased. Several of these engines with the low igniter were built and sent out and shortly after returned to the shop because they used too much gas. Although the igniter in its new position was far closer to the inlet valve, yet the charge passed by the igniter and became stratified in another part of the cylinder, leaving the part around the igniter very poor in gas. To overcome this, it was decided to place a hood inside the head, over the inlet valve, in order to deflect the charge against the igniter. What was the result? The charge at the igniter was so rich in gas that when the explosion occurred it was so early and severe that the shock in the engine could be heard quite a distance away, and would soon have made the engine fit only for the scrap pile. The only thing to do in this case was to give very little lead to the engine with a consequent large loss of power. At my earnest solicitation the igniter was raised up a little and we had a test of the two styles. Both engines were of 8-inch bore and 16-inch stroke. The engine with the low-down igniter was running a chopper and all that could be got out of it was fifteen bags of chop an hour with the engine loaded to its limit. We removed that cylinder and replaced it with one that had the igniter raised.

At the first test with this engine we chopped thirty-four bags of chop in one hour, and at a second test we chopped thirty-two bags in one hour. In this latter trial the engine was not loaded to its limit, so could have done even better, and this was accomplished with nearly 25 per cent. less gas than the other style of cylinder required to chop fifteen bags. I also took a break test of the engine with the igniter raised and it gave 24.4 horse power. Not a bad showing for an engine of that size.

If it were possible to build a four-cycle engine in which the charge could be thoroughly mixed before ignition the question of the position of the igniter would not be of nearly so much importance. But engines are now built to run at two, three, or four hundred revolutions per minute, and competition being so keen, the question of cheapness of manufacture is of vital importance. Attempts more or less successful—generally less—have been made to overcome the difficulty, but most manufacturers and purchasers of gas engines want them as simple as can be made and with as few clap-traps as possible. This being the case, the writer is convinced that the only way to get the maximum amount of power with the minimum consumption of fuel is to place the igniter on the engine according to the size of the engine and the design of the inlet valve and passages, so that the charge that comes in contact with the igniter will be of the proper mixture for each particular size and design. When this is done a gasoline engine will run as smoothly and quietly as a steam engine, without the slightest shock, and with the added advantage that there will be a considerable increase in power, and a greatly increased economy in the consumption of fuel over present makes of gasoline engines.

* * *

BENDING ANGLES AND STRUCTURAL SHAPES.

FRANK B. KLEINHANS

Considerable difficulty is experienced in bending angles into circles for tanks, etc. The angles are bent either as shown in Fig. 1 with the leg extending in, or like Fig. 2 with the leg extending out, but unless the work is done properly, the

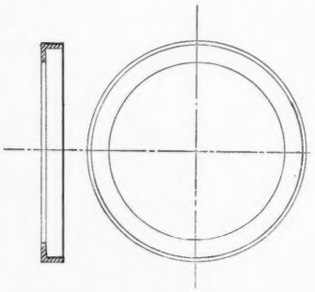


Fig. 1.

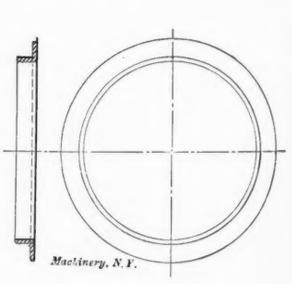


Fig. 2.

legs of the angles will not lie flat, being dished in or out as the case may be. In bending an angle as shown in Fig. 3, the lower portion *A* must be stretched and the top portion *B* must be compressed. On account of the fillet *F*, the bottom

roll will have only a short bearing along the flat portion between the fillets, while the top roll will have a bearing over the full face of the angle. The center of gravity of the downward thrust is not in the same plane as the center of gravity of the upward thrust, and on account of these forces acting in different planes the angle will twist, and when it is bent will not lie flat. This difficulty is not easily remedied on every style of bender, but usually it is possible to rig up a bender with special attachment which will turn out satisfactory work.

There are two general types of benders, the double housing type and the overhung type. Benders of the double housing type have the rolls between two housings, the driving gear being placed next to the rolls or outside the housing. These machines can bend very heavy material in comparison with

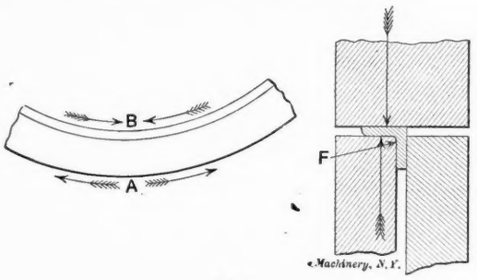


Fig. 3.

their weight, but to offset this the rolls are hard to change, and the material after it has been bent, is not easily taken out of the machine. Benders of the overhung type are heavy machines in comparison with the stock which they will bend. To offset this, however, the rolls are easily adjusted and can readily be taken off and replaced with rolls of a different shape. Whichever type of machine is used for bending, the grooved rolls should be made in separate pieces as shown in

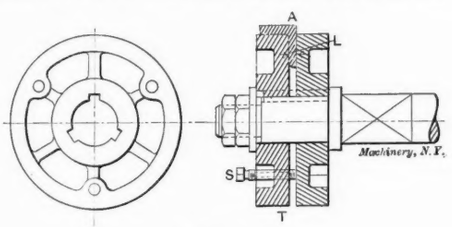


Fig. 4.

Fig. 4. Some form of adjustment, as a setscrew *S*, should be provided for changing the width of the slot *T*, and the rolls should then be adjusted so that the leg *L* of the angle *A* has little if any play. It is convenient in bending angles to have all these rolls arranged with adjustment similar to that in Fig. 4. One can then bend an angle into a circle with the leg either in or out as shown in Figs. 1 and 2, though with the machine arranged in this way it is still almost impossible to bend angles so that they will lie flat.

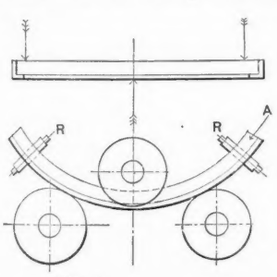


Fig. 5.

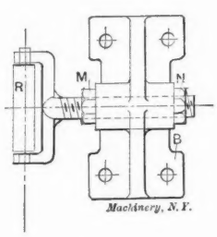


Fig. 6.

Fig. 5 shows a set of bending rolls where *A* is an angle which has been bent as shown, and *R* and *R* are rollers attached to the housing of the machine. As the angle is being bent, the dished side will bend toward or away from the housing, according to the way in which it is passed through the machine. The angle is now entered into the machine so that the dished side will bend toward the housing. The rolls *R* and *R* are adjusted against the angle and the angle is run through the rolls back and forth, the guide rollers *R* and *R* being screwed out until the angle, after it is bent, has all the dish taken out of it. A person can soon become experienced enough to bend angles which will lie on a flat surface. Fig. 6 shows a detail arrangement of a guide roller, *R*, with the adjusting nuts *M* and *N*. The bracket *B* is either bolted or cast solid on the housing. Fig. 7 shows the top roll *T* adjusted out over the angle to be bent. In bending light angles on machines which have light rolls, the leg will sometimes buckle. To prevent this a separate guide angle *G* is run in alongside of the angle *A*, to keep the leg from buckling and twisting out of shape, and this in a measure serves the purpose of the guide rolls.

In bending tees, channels and rails, the rolls gradually become worn, then the work will be sure to be cupped one way or the other. Sometimes this can be corrected by adjusting the rolls, but frequently the guide rolls, Figs. 5 and 6, are required for bending the work into a perfect plane. In reference

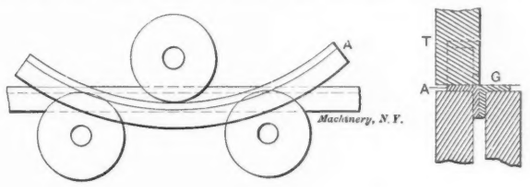


Fig. 7.

to bending rails it might be well to mention that owing to the heavy sections there is little spring in the rails in the short length between the lower rolls. For this reason the rolls will either grip the material so as to stall the machine or else the rolls will slip, especially where the top roll is idle. If the top roll is driven, however, the rail will be drawn through the rolls better and the bending action will be more uniform, though there is always more or less slip between the rolls and the section which is being bent. The scale often snaps away from the material and catches between the section and the rolls, and thus the surface of the rolls becomes badly worn. For this reason it is well to have the rolls chilled, and moreover, since the chilled surface is very hard, there will be less likelihood of chipping or breaking the edges and corners.

* * *

ELECTRIC REPAIRING.

ARMATURE COILS.

NORMAN G. MEADE.

An illustration of an armature coil of the most common type now in use, is given in Fig. 1. This coil requires somewhat more labor to prepare than does the rectangular form, but is much easier to use when rewinding armatures, as no portion of it passes over the end; and it has the further advantage of allowing better ventilation. Another type in use is the plain, rectangular form, shown in Fig. 6. Such a coil

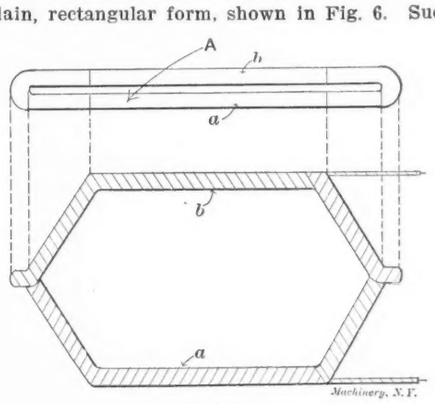


Fig. 1.

is easily made, but requires considerable manipulation after it is placed in the armature. The forms over which these two styles of coils are wound are similar in design but different in shape. Fig. 2 shows a form, in which *a* is a standard fastened to bench or floor, and a slot is cut down through the center of this standard to a point two or three inches below the crank. A small bolt, *l*, with thumb-nut, is provided, to place a tension on the crank, by drawing up the slot. This is

plainly shown in the figure. For the form proper we require a piece of hard wood, *b*, rounded at the ends, *d* and *d'*, the size and shape of this piece conforming to the interior of the coil to be wound; and two side pieces of wood, *c* and *c'*, slightly greater in dimensions than the center piece, so that when placed on either side concentrically with the center, a spool is formed. The side, *c*, is fastened permanently to *b*, while *c'* is held in place by two thumb-nuts, *e* and *e'*, which allows the coil to be readily detached from the form.

The flange, *f*, is attached to the short shaft with crank and handle, *j*. The illustration shows both plan and side views.

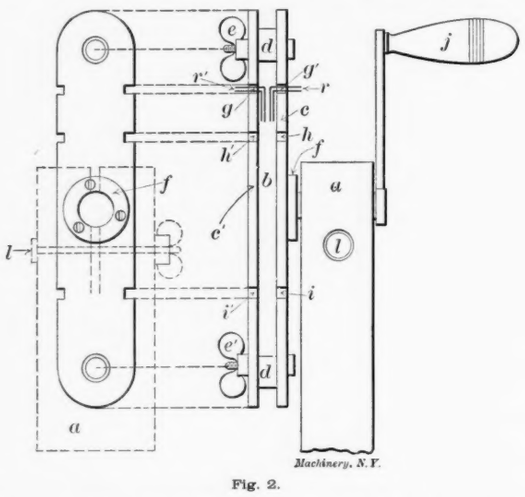


Fig. 2.

The notches, *g* and *g'*, *h* and *h'*, *i* and *i'*, are for fastening the ends of the wire and for the retaining strips, which will be explained later.

Fig. 3 gives plan and end views of the shaper for shaping coils of the style shown in Fig. 1, in which *g* is the wood base, *a* is the coil that has been shaped, *b* and *b'* the clamps; *c*, *d*, *e* and *f* the wood strips, of the shape indicated. The pieces *d* and *e* are fastened to the base, *g*, by screws. The operation of this shaper will be taken up in its turn.

Fig. 4 represents a reel of magnet wire, *a*, swung on a suitable support, *b*, and provided with a tension. The tension consists of a piece of hard brass wire, about No. 10 or 12, fastened to base *b* and passing around a groove in one side of the reel

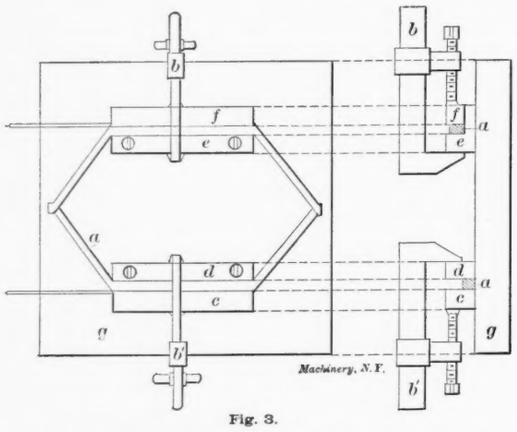


Fig. 3.

to a weight, *d*. With the wire, *e*, paying off in the direction indicated, the desired amount of tension may be placed on the reel by varying the size of the weight.

Fig. 5 represents a handle for guiding the wire onto the form. This handle should be made of fiber or hard wood. The end, *c*, is beveled off as shown. A hole or slot, *b*, extends through the handle, through which the wires pass. The handle is held in the left hand, while the form is rotated with the right hand by means of the crank already mentioned.

Some styles of coils are wound with two or more wires laid on in parallel at one time. The reason for this is that in machines of considerable size, a single conductor of sufficient carrying capacity would be too stiff for handling. Under such conditions the handle should have a slot at *b* instead of a hole, and a separate reel for each conductor should be provided, one placed back of the other.

The materials used in armature coils are: Double, cotton-covered magnet wire, ½ or ¾-inch cotton tape, insulating tape, a good quality of orange sheliac, and some strips of 1-32-inch sheet brass. The cotton tape can be procured at any department store in rolls of various sizes.

A drying oven is an essential part of an electrical repair shop, and when there is steam or gas in the building it is an easy matter to provide one. Its capacity must be determined by the size and quantity of the work to be done. An angle-iron frame, with 1-16-inch iron or steel lagging for siding and doors, makes an excellent oven. The doors should be on the front and extend from top to bottom. The interior of the oven must be provided at the lower portion with a suitable stand for holding armatures, and above the stand metal racks, for drying coils and commutators. Steam coils or gas burners may be used for heating the oven. A good temperature for drying is about 200 degrees F. Too much care cannot be taken in following the dimensions of old coils, as a little variation will cause trouble when placing the new coils in an armature.

In general, do not use metal for driving wires into place; use hard wood or fiber. If any bare spots appear in course of winding, insulate them at once. Do not cut the ends of the wire too short. It is easier to cut off a little more than to splice on. Tape the coils tightly and let the convolutions lap well, so that they will not pull apart when shaped. The lead wires, or ends of coils, should be carefully covered with insulating tape. Soldering in of lead wires is greatly facilitated by tinning the ends before driving them into the com-

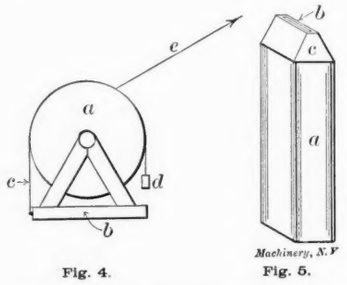


Fig. 4.

Fig. 5.

mutator slots. The beginner, undoubtedly, will have to make several attempts before completing a perfect coil. Neatness is of great importance, and every portion should be well done before proceeding further.

We will now wind and insulate a coil, and follow out each detail. Assume that a set of coils, similar to that shown in Fig. 1, is to be made. It is supposed that the winder has one of the old coils for inspection. With a wire-gage determine the size of wire, and note whether one or more wires are run in parallel for one conductor. This done, carefully unwind one turn and measure its length; this will be the circumference of the form to wind the new coil on. A coil of this style should be wound on a long, narrow form, similar to that shown in Fig. 2. Some armatures have two coils per slot, that is, two coils made up as one, with their respective ends brought out separately. Consider that we are about to wind a double coil, with two wires in parallel for one conductor. This will necessitate winding on four wires at one time.

Arrange four reels of magnet wire, one back of the other, and push the four ends through the slot in one guide. Suppose the desired length of the armature leads, or coil ends, to be six inches. Now bend at right angles the two right-hand wires, about six inches from the ends passed through the guide, then bend the two left-hand wires in the opposite direction. This being done, slip the two pairs of bent ends into the slots *g* and *g'* in the manner shown at *r* and *r'*, Fig. 2. Say that the coil is four convolutions wide and three layers deep. Having secured the ends as described, turn the crank two and one-half times, bringing the outer ends of the coil through the slots on the opposite side to *g* and *g'*, using care to retain the ends in their original order. During the winding

process the guide should be held firmly in the left hand, and the wires pulled down tightly into the form. Now cut off the wires from the reels, leaving six-inch ends on the coil, as at the beginning.

Cut four narrow strips of 1-32-inch brass, about 1 inch long, and slip one under the coil through the slots *h* and *h'*, *i* and *i'*, and also through the four corresponding slots on the opposite side of the form. Bend the strips up over the coil, and tap down lightly with a mallet, taking care not to break the insulation. Loosen the thumb-nuts, *e* and *e'*, slip off the side *c'*, and remove the coil. Make up the desired number of coils in this manner before insulating them. Having completed the winding, cover with good insulating tape the four ends—that is, the eight wires. These leads should be covered from the point where they bend through slots in the form, to about one inch from the end.

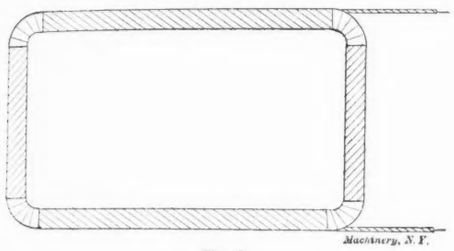


Fig. 6.

The next operation is to carefully wrap the whole coil with cotton tape, giving it the appearance shown in Fig. 1. The leads must be left protruding the distance covered with insulating tape.

We will now shape the coil, as in Fig. 3. The two halves of the coil, after being taped, should be pressed closer together, giving the coil the appearance shown at *A*, Fig. 1. Insert one of the halves between the strips *c* and *d*, and clamp it tightly. With the protruding half grasped with both hands, pull it over the strip, *e*, and clamp as shown. With a small fiber mallet, pound the ends into symmetrical shape. Remove from shaper, and immerse in a suitable receptacle filled with thin shellac. When thoroughly impregnated, allow superfluous shellac to drip off, and place in oven to bake.

The rectangular coil shown in Fig. 6 can be made on a form similar to the one described, having its dimensions correspond to the shape of the coil.

A little practice will render the workman proficient, and enable him to turn out as good work as can be purchased from electric manufacturing companies.

* * *

THE AMERICAN BLOWER CO.'S NEW ENGINE.

The small vertical engine shown in the two views herewith has recently been placed on the market by the American Blower Co., Detroit, Mich., for continuous operation and heavy duty as in driving blowers, dynamos, pumps, etc. From Fig. 1 it will be seen that it is fully enclosed, preventing foreign matter getting into the working parts; all these parts are accessible by turning a milled hand nut and lifting out the enclosing plates. The builders state that for the past two years they have been experimenting with this engine, and in this connection they inform us that an engine was adjusted and filled with oil on March 10 and that up to July 15 no adjustments of any kind had been made, and no oil added except to fill the sight-feed cylinder lubricator. They further state that it has been operating from 14 to 16 hours per day, driving a blower, and that after a lapse of over four months it needed no adjustment or fresh lubricant, running almost as noiselessly as at first. Fig. 2 illustrates the oiling system, which is a special feature of this engine.

Referring to the half-tone, Fig. 2, the operation is as follows: An eccentric, *K*, on the shaft, actuates the plunger, *L*, of the oil pump, *A*, forcing the oil up through the tube *B* into the small strainer, *C*. From *C* it drops into an oil box through the bottom of which four tubes project. In one side of each of these tubes is a slot, so that if the oil box contains only a small amount of oil, each tube can take its proper proportion. If the box is full, all the tubes get more oil in proportion to the increased height. Two of these tubes, *F* and *C*, and two on the opposite side, not lettered, apply oil to the guides, the oil dropping into a small trench, *G*, from which it runs into the bearing through a small oil hole. The crosshead pin is supplied by the tube *E;* the oil drops into the cup, *H*, and the cavity between the bolt and inside of crosshead pin and the oil grooves. The oil dropping from the crosshead is caught in two pans attached to the inside of the covers, from which it runs down the inside of the cover and drops into a cup in the

Fig. 1.

top of the main bearing cap. There are no oil grooves at top and bottom of the main bearing, as is customary, but the bearing is cut away at the joint. When the strain from the connecting rod is up the oil is carried to the bottom of the bearing, but when the load is reversed there are no oil grooves to carry away this oil. The crankpin is oiled through tube *D*, which discharges into a crank oil ring inside the eccentric, *K*, which, in turn, discharges into the crankpin oil tube, and flows across the crankpin bearing. The crankpin oil ring, in addition to its independent supply, catches the drip from one

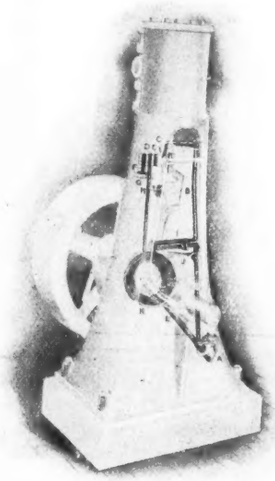


Fig. 2.

end of the main bearing; the eccentric is oiled from the drip which it catches from the other end. No difficulty has been experienced in catching the oil thrown off the eccentric strap. A portion of the oil, as it drops back into the bottom of the frame, enters an oil filter thoroughly cleaned and purified.

* * *

Electric power generated at Niagara Falls was first used commercially by the Pittsburg Reduction Company, August 26, 1895. Work on the development of the power station was started by the Niagara Falls Power Company October 4, 1890, and work on the tunnel tailrace was carried on unceasingly for nearly five years.

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JIGS AND FIXTURES—HOW DEFINED?

We have been asked to define the words "jig" and "fixture" as applied to machine tool equipment, and to advise which word, in our opinion, is preferable. A glance at the definitions of these words in the Standard and Century dictionaries soon convinced us that the learned gentlemen who compiled these excellent works had not given the important subject of interchangeable manufacturing a great deal of their attention. The Standard says that a jig is "any tool or fixture used in the manufacture of duplicate parts to guide cutting tools so that their operations shall be the same on each; as a drilling-jig, or a milling-jig." No definition of fixture, in this sense, is given whatever, and the Century ignores both words as applied to duplicate manufacturing. Hence it was "up to us" to determine the meaning and limitation of each word as used in the shop and trade literature, and we find it to be by no means an easy matter.

In the first place jig and fixture are words used interchangeably; a drilling-jig and a drilling-fixture may be one and the same thing—and they may be different, as we shall see later. Broadly, a jig is a device used in interchangeable manufacturing of machine parts *for holding the work pieces* and *guiding cutting tools* in any machining operation thereon; hence it may be used for drilling, boring, milling, planing, shaping, etc., but, we believe, it is preferably limited in general use to the first two operations, that is, drilling and boring.

While fixture is a term generally used to mean the same things, we believe that it is more comprehensive, and that it includes a lot of things which would not ordinarily be called jigs. In this we take issue with Mr. Mirrielees, who in another part of this issue uses the word jig throughout his article to include all templets, fixtures, appliances, etc. Now if the device is of such a nature that it incloses and holds the work so that it can be lifted and transported as a whole, and, perhaps, has provision for a number of operations in different planes, we should surely call it a jig, but if it were the radius attachment to a planer for planing locomotive links, we should call it a fixture, although it is by no means a fixed or permanent part of the machine. A drilling vise is more of a fixture than a jig, but if it is provided with guide bushings we would term it a drill-jig or a jig-vise. Again a fixture may be one of the tools of a machine, as for example, the tools and fixtures of a turret lathe. A tool-post is an example of a fixture, but it is not a jig in the ordinary sense of the word. An "old man" for ratchet drilling is a fixture, as is also a former used on a planer as in planing relief for locomotive driving boxes, or as applied to the lathe for turning machine handles. A bending device which insures exact duplication is usually called a fixture, in preference to jig. A device for holding work pieces on the milling machine so as to insure duplication of parts, is preferably called a fixture, although in many shops it would be called a jig. Hence the difficulty in assigning any definite and limiting meaning for either term.

One difference that may be assumed to exist between jig and fixture is that a jig holds the work and guides the cutting tool *independently* of the machine supplying the driving power and feed, while the fixture is usually dependent upon the machine to guide the cutting tool or the work; one is self-contained and the other is not. We are fully aware that this distinction does not exist in actual practice, but it is one put forward as a suggestion for those shops which wish to define shop terms precisely.

* * *

IMPROVED LUBRICATION.

Improved lubrication is a feature of modern machine design that is one cause of greatly increased efficiency. In the old time machines the builders were often content with merely a hole drilled through the top of the bearing, through which an occasional squirt of oil could be injected. With slow-moving parts this makeshift lubrication permitted machinery to be run without actually grinding out the journals, but the frictional resistance was high and wear comparatively rapid; with modern high-speed machinery it is necessary to have something better. Following the primitive oil hole came the self-feeding oil cup which required to be filled only at intervals and maintained a steady supply, drop by drop, of oil upon the bearing. Where there are a great number of bearings, the filling and supervision of a large number of oil cups requires much time, and if any one oil cup is neglected, a hot bearing may result, causing the shutting down of an important machine. In many cases, especially in central power plants, no chances can be taken from interruptions of service, and lubricating systems have been developed by which oil is pumped from one source through pipes to all the various bearings that require lubrication. Instead of being content with drop by drop lubrication it has come to be the custom to flood the bearings with oil, which, of course, is returned to the central system to be pumped over again. The temperature of bearings can be kept several degrees cooler in this way, and the coefficient of friction may be materially reduced. But with this system of oil distribution on steam engines it has not heretofore been considered feasible to lubricate all the main working parts in the manner described. Recently, however, an improved form of steam engine was put on the market which has a crankshaft made so that the oil injected into the main bearings travels thence through the crankshaft to the crank-pin, and from the crank-pin through a hollow connecting rod to the crosshead bearing and the guides. The valve stem guides also receive lubrication from the crosshead guides. Tests have shown the efficiency of the engine as a machine to be considerably increased, and, of course, all bearings by this system are working under almost ideal conditions as regards lubrication. Hence there should be practically no trouble from hot journals or cut boxes.

* * *

The Electric Controller & Supply Co., Cleveland, O., recently wished to relieve their representative at the Louisiana Purchase Exposition, and as a means of selecting the best man to take the position inaugurated a contest among their draftsmen. The contest consisted of two written articles and the award was made as follows: 40 points were counted for the clearest description of a certain specified apparatus; 30 points for the best statement of the advantages of the apparatus from the standpoint of a customer; and 30 points for the best composition from the standpoint of rhetoric and grammar. The competition was won by Mr. George W. Magelhaes, formerly a student of the Case School of Applied Science, and later of Columbia University.

ENGINEERING REVIEW.

CURRENT EVENTS, TECHNICAL AND MECHANICAL—LEADING ARTICLES OF THE MONTH.

A reinforced concrete chimney 182 feet high has recently been completed for the Portland Cement Co., of Belleview, Mich. The *Engineering News* states that the structure is monolithic throughout, the reinforcement being on the Weber system, using light steel bars of T-section. The interior diameter of the chimney is 8 feet.

The rival of the locomotive, the high-speed automobile, has again lowered its record, the quickest mile to date being that made by H. C. Bowden on a mile straightaway course at Ormond, Fla., January 15. With a 90 horse power French machine Mr. Bowden made a mile in 37 seconds against a stiff northeast wind. The track is located on the beach, where the sand, by the action of the wind and waves, is made remarkably smooth and hard, forming an ideal course for automobile speeding.

The Butterick Publishing Company, New York, have what is said to be the largest electric sign in existence on the west side of their new building overlooking the Hudson River. It consists of the word "Butterick" in enormous letters extending across the length of the structure and of a height proportional to their width, the "B" being nearly six stories high. The lamps lighting the sign are divided into three sections, each section of three letters being on independent circuits controlled by switches on the power plant switchboard. Incidentally this arrangement went wrong one night, one of the circuits failing to work through the blowing of a fuse or some other defect, and the New Jersey commuters crossing the river were amused to see this enormous sign advertising "Butter."

A useful method of repairing cracks in castings, such as locomotive cylinders is described by a correspondent of the *American Engineer*. Where a crack is to be drawn together the ordinary method is to bolt forgings with projecting ears on each side of the crack and through these ears put bolts for drawing the adjacent sides together. This makes a clumsy looking job and in some cases it is difficult to get the necessary strength in the repair to hold the parts firmly in place. The alternative method referred to by the correspondent is as follows: A piece of iron 1¼ inches thick was turned to about 8 inches in diameter and then cut through the center, making two semi-circular pieces. These were fastened by ⅞ inch patch-bolts on either side of the crack in such a position that their contours would form a circle. The cut through the center represents about the allowance for drawing the crack together. A heavy band of iron was then shrunk on the pieces, drawing the crack tightly together and making a steam-tight joint. This method of cylinder repair does not interfere with the jacket; as the lagging can be fitted around it, making the top of the plate flush.

The new *Times* building is the last word to date in the matter of tall buildings in New York City, being over 9 feet higher than the Park Row building when measured from its lowest basement floor, 57 feet below the street, to the topmost point. The *Times* building measures 419 feet 9 inches over all and the Park Row building 410 feet, but the Park Row building is higher from the curb line, being 380 feet, while the *Times* building is 362 feet 8 inches. This building is notable in more ways than one, however. It is situated on a trapezoidal plot of land bounded by Broadway, Seventh Avenue, Forty-second and Forty-third Streets, thus giving the building the advantage of light on all sides and the unique distinction of having more than three times the area in vault space than the nominal area of the lot. The area of the building lot is 5,405 square feet; total area including vaults, which go to the curb line, 17,633 square feet. The New York Subway traverses one corner of the upper basement, and a local station at this point permits the tenants of the building to enter the Subway without going on the street. The building contains a total floor space of 116,349 square feet, 3,712 tons of structural steel, a smokestack 389 feet high, a 30-ton steel girder, the heaviest girder ever used in the construction of an office building, an elevator rise of 326 feet, and many other features of notable distinction. The printing is done in the sub-basement where there are four Hoe octuple presses having a theoretical capacity of 192,000 16-page papers an hour, but an actual output of about 144,000 on account of delays from stops, changing rolls, breaks in the web, etc.

In view of the fact that New York City is experimenting extensively with wood pavement, the report of U. S. Consul Hamm of Hull, England, on wood pavements in that city is of much interest to municipal officers responsible for the maintenance of streets. Hull now has thirteen miles of wood pavement, and wood is being substituted for granite blocks in streets originally paved with the latter material, its use beginning in that city in 1875. The woods which have given the best satisfaction are obtained in West Australia, and are known as "jarrah" and "karri." The blocks are cut 3 inches thick, 4⅜ inches wide, and 9 inches long, and are dipped on one side and end in a hot mixture of pitch and tar. They are laid close together, edge up, that is with the grain standing vertically, and the joints are run full of the hot mixture of pitch and tar. The pavement is frequently sprinkled with coarse grit, which tends to give a continuous surface almost as hard as granite. Wood pavement laid in Hull in 1894 is still in good condition, but the principal reason for their durability is the fact that a first-class foundation of cement concrete 7 inches thick is first put down, and this is faced with Portland cement mortar, three parts sand and one part cement, which forms a perfectly smooth surface for the blocks, and supports them rigidly under heavy loads.

A new method of laying electric cables which has been adopted in the Poplar district of London, in lieu of the system of inclosing the cable in an iron or earthenware conduit, is described in the *Scientific American*. The cables are laid separately in a corresponding number of light steel pipes. These pipes are coated upon the exterior with a special preparation in which paraffin wax predominates. They are made in 5-foot lengths, and are jointed by ends which screw into one another, leaving a flush surface, until a tube of 200 feet has been formed. This length of tubing is then laid in the trench, and covered all around with a layer of concrete, which is allowed to set. This accomplished, the steel pipes, which only serve as a mandrel on which to form the concrete duct, are withdrawn by the application of steam, which is driven into them under pressure. The heat thus applied melts the preparation around the pipes, and as this also acts as a lubricant, the pipes can be withdrawn quickly and easily by winch and rope. As each 5-foot section of piping is withdrawn, it is unscrewed and coated again for further use. By this ingenious process a concrete conduit of perfectly symmetrical form is obtained for the accommodation of the cables. These are drawn into the duct in the usual manner, the lubricant that remains inside considerably facilitating the operation. More than 100,000 feet of cables have been laid in this manner in Poplar, the process having proved completely successful.

The results of some tests on hard solders for steel brazing made by the British National Physical Laboratory were published in the October 28, 1904, issue of *Engineering* (London), from which it appears that the presence of iron in small quantities and of lead of approximately, or over, one per cent, is detrimental to the strength and flushing quality of the solder. Spelter or solder made up of copper, 52.53; zinc, 45.46; lead, 1.35; and iron, 0.42, was found unsatisfactory for mild steel (0.3 to 0.35 carbon) brazing. With the proportions: copper, 63.19; zinc, 36.31; and lead, 0.65, the spelter was found to have

a fairly high melting range, good flushing quality (spreads well) and good tenacity, the strength of a brazed joint being over 9,500 pounds per square inch of brazed section. As the proportion of zinc to copper is increased, the temperature of melting decreases, giving a low range. Hence such spelters are bad for brazing steel, as the latter metal cannot be made sufficiently hot to get a perfect union. Hence the following result with copper, 49.76; zinc, 49.16; and lead, 0.98. The flushing was good, but the tenacity was low, falling to about 7,400 pounds per square inch of brazed section. The introduction of iron into spelters generally comes from the use of an iron rod for stirring the molten spelter in the process of manufacture, and the practice is one that should be avoided.

In regard to work of an intermittent character some one has said that the steam engine works by the day and the electric motor by the piece. In other words, the boiler burns coal all the time whether the engine runs or not, but expense with the electric motor is only incurred while it is actually running. This fact would seem to make the electric motor for some classes of contracting a source of power preferable to the donkey engine and boiler commonly used on such work. This of course applies to cities and districts where electric power from service mains is available, but when we consider the vast amount of excavating and similar work in large cities that requires power, it seems that the average contractor does not appreciate the full value of the electric motor as he should. There are of course difficulties in the way of using the "juice," and perhaps the electric companies themselves have not encouraged this demand. A writer in the *Western Electrician* says, in an article on the subject, that the contractor having to pump out an excavation generally uses two laborers to a pump, and although he may use arc or incandescent light at night to enable the work to be pushed hard and fast throughout the whole twenty-four hours, never seems to think of using a motor-driven pump for the job, thereby saving the laborers' pay. It might be added that cutting down expense for lighting, which would be largely unnecessary with the motor-driven pump, would largely compensate for the power required to drive the pump.

In an article upon pipes and joints for high pressure read by Mr. Franklin Riffle before the Technical Society of the Pacific Coast, May 27, 1904, a variety of pipe joints adapted to high pressure pipe lines was described. The simplest line pipe coupling for high-pressure service is a modified form of the standard pipe coupling, from which it differs in that the coupling is made longer and heavier. It is recessed for a short distance at the ends to the exact diameter of the outside of the pipe; thence it is threaded, the thread having a taper to the center of ¾ inch per foot to correspond to the standard taper of pipe thread. By recessing the ends of the coupling and making the ends of the coupling snugly fit the pipe, the liability of fracture through the thread is largely reduced, inasmuch as the coupling bears upon the pipe joint beyond the threaded portion. The writer puts special stress upon making the taper of the thread in the coupling exactly correspond to the taper of thread on the pipe in order to secure a tight joint, as this insures a perfect contact for every thread. We believe, however, that Professor Sweet advocates making the taper of a thread somewhat less than the taper of the hole, to compensate for the additional wear to which this part is subjected in screwing it home, and because of its thinner section, which causes it to compress more easily than the thicker parts. By making the taper of the pipe about ⅝ inch per foot, Professor Sweet calculates that, in average practice, the pipe and coupling will be in uniform contact throughout when screwed into place.

Plans for additional subways for New York have been proposed by Mr. William Barclay Parsons, and submitted by him to the Rapid Transit Commission, of which he is the chief engineer. These plans differ from any heretofore proposed and contemplate additional lines in Manhattan, the Bronx, and Brooklyn. A new line on the east side of New York is provided for, to run from the Battery to East One Hundred and Forty-ninth Street in the Bronx, with a two-storied subway in Lexington Avenue; a new line on the west side, from the Battery to Forty-second Street, where it is to connect with the present subway; a cross-town connecting line at Thirty-fourth Street, between Seventh and Park Avenues, and a diversion of the proposed Fourth Avenue line to Fort Hamilton in Brooklyn, to Hamilton Avenue, thence under the channel to Governor's Island and on to the Battery, in Manhattan, whence it is to run under Greenwich Street to connect at Barclay Street with a low level loop of the proposed new west side route.

The plan proposes for the Borough of the Bronx, an extension of the west side line from Kingsbridge to Van Cortlandt Park, and a lengthening of the present east side line from its terminus at One Hundred and Eightieth Street, under Bronx Park to the city line. It is also proposed to extend the elevated railway from One Hundred and Fifty-fifth Street, on the west side across the Harlem River, to Woodlawn, to extend the elevated lines in Brooklyn, and to build two additional tracks on the Second Avenue "L" line, in Manhattan, for express trains.

The cost of the proposed new lines, as estimated, would be $40,000,000 in Manhattan, and for subway extension in Brooklyn and the Bronx, $9,000,000.

CHARACTERISTICS OF BRONZES.

In speaking before the Franklin Institute on the "Physical Characteristics of Certain Bronzes for Steam Uses," as reported in the *Journal of the Franklin Institute* for January, S. L. Kneass stated that the copper-tin alloys in general vary from 5 to 24 parts by weight of copper to 1 of tin, with a small percentage of lead or zinc or of both. The true binary alloy is little used, because the addition of other metals, such as lead, zinc, nickel, phosphorus or aluminum to the copper and tin, adds useful qualities and reduces cost of machining. For example, a trace of zinc is used in a 5 to 1 mixture for certain kinds of spindle-bearings or sleeve nuts, producing a hard and brittle metal, machining with a short chip which flies from the tool with great force. It is somewhat difficult with this to get a smooth surface, but the bearing wears well under heavy pressures. A good hydraulic bronze is made of a ratio of 7 copper to 1 of tin, and a little more zinc. This has sufficiently high tensile strength, machines well, and runs solid in the mold.

The essential characteristics of a good steam metal are homogeneity, solidity, tensile strength, rigidity, facility for machining, fluidity in casting, and non-corrosiveness. Homogeneity is much more difficult to obtain in an alloy composed of copper, tin, lead and zinc than in a mixture of copper and tin alone. The rapidity of melting, temperature of pouring, and the condition of the mold, as well as the form and size of the section and rapidity of cooling, all have an influence on the homogeneity, although imperfect mixing is probably the chief cause of trouble in this respect. Tensile strength and rigidity depend upon the proportion of copper to tin and their preponderance over the lead and zinc, while the character of the chip is determined chiefly by the percentage of lead, and the fluidity by the zinc. The proper mixture for any purpose must be a compromise, with a tendency toward homogeneity and density.

Bronze castings in service are subjected to two serious deteriorating agencies, the attrition or wearing away due to the passage of water, sand, etc., over them, and the solvent action of the contained fluids in the casting. The more soluble metals in the bronze are apt to be dissolved by acidulous or alkaline elements in the alloy, causing porousness and possible leaks. The abrasive effect of water, sand, etc., is in some cases seen to be considerable. The jet of an injector may have a velocity of 800 feet per second, and a pressure against the walls of the tube of 80 to 100 pounds per square inch. Hydraulic valves made of bronze are often subjected to a pressure of 4,000 pounds per square inch, and the velocity of the water or oil through them may reach 2,400 feet per second during opening or closing. In such cases any defect in the bronze is sure to cause rapid deterioration in the efficiency of the device.

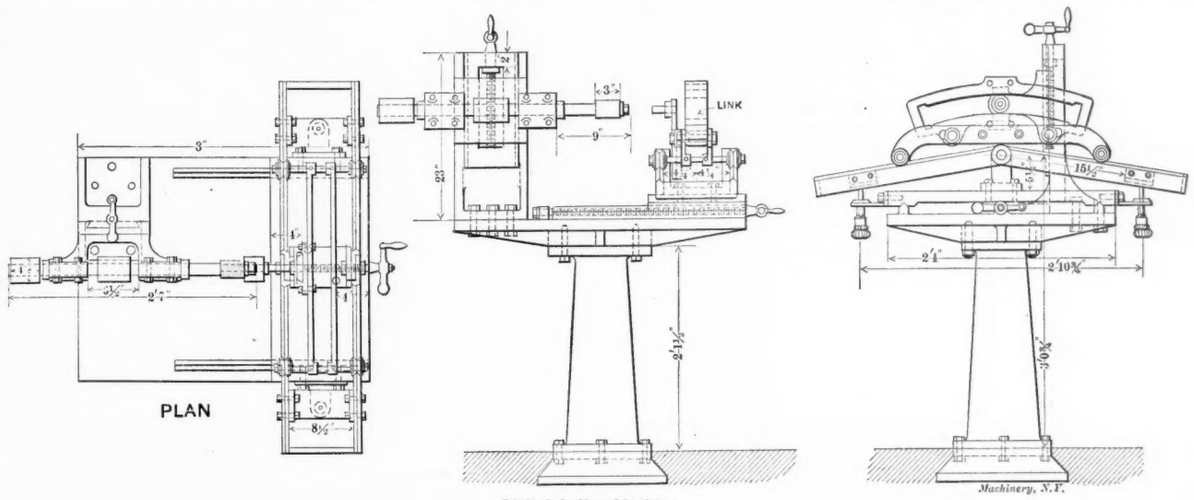
Careless mixing of the fluid metal before pouring is an ob-

vious cause in the variation of quality in bronzes. An extreme case was proved by specimens taken from castings poured from the top and bottom of a bail-pot without special stirring. Only a trace of lead was found in the specimens from the top and three times the required amount in those from the bottom, neither being fit to use.

The effect of rapid cooling is beneficial, increasing the density, reducing porosity and making the section more uniform. A casting poured in an iron mold should have a closer grain, higher tensile strength, and greater specific gravity than if poured in sand.

LINK GRINDING MACHINE.

In the November issue of the *Railway Master Mechanic* a link grinding machine was illustrated, which was designed by Mr. James F. DeVoy, and is now in use in the West Milwaukee shops of the Chicago, Milwaukee and St. Paul Railway. The machine is supported by a cast iron pedestal bolted to the floor, and the several moving parts rest upon a cast iron bedplate, which is secured to the supporting pedestal. The link is bolted to a pair of light brackets, so arranged as to constitute a carriage. This is carried on two pairs of rollers, one pair being located at each end. The rollers traverse a set of guides which are supported at the center, about which they may be rotated within narrow limits, and are adjustable at the outer ends by micrometer screws. These guides are carried upon an upper bedplate, which in turn is arranged to slide transversely on guides which are cast to the principal bedplate. Transverse motion is given thereto by a crank handle and horizontal feed screw. The holes in the link brackets through which the link is bolted, are made oblong in order to fit the several sizes of links in service on the different classes of locomotives. When the link has been placed in position the roller guides are adjusted by the micrometer screws to obtain the exact radius desired for the link. The upper table is then moved transversely to such position that the emery wheel engages the surface of the link. The link bracket is then moved back and forth by hand, rolling up and down along the guides, the motion being such that the link is vibrated in an arc of a true circle. For grinding link blocks a small cast iron bracket is provided. This bracket, when in use, is bolted to the link bracket nearer the emery wheel stand, two holes being drilled in the nearer link bracket to coincide with the bolt holes in the link block bracket. The emery wheel is driven by a belt from the countershaft above and is so arranged that it may be raised and lowered by a hand crank and vertical feed screw. A noticeable feature of this machine is the small amount of space which it covers, as compared with other devices for the same work.



Link Grinding Machine.

COMPARISONS AND NOTES ON PRIME MOVERS.

Abstract of Article by William McClellan, Ph.D., Engineering News, December 29, 1904.

The relative standing of the chief types of prime movers is at present so unstable that a prominent engineer lately declared that he would not dare, at this time, install a large steam engine plant, or even one of steam turbines, for fear that before he got it running he would wish he had put in gas engines. Nevertheless, in this country, there are some engineers who refuse to consider any type but the reciprocating steam engine. To sum up what may be said for the various types, considering plants of not less than 1,000 H. P., prime movers may first be classified as follows: *Steam:* (1) Engine; (2) Turbine. *Gas:* (3) Engine; (4) Turbine. *Oil:* (5) Engine, explosion type; (6) Engine, Diesel type. *Water:* (7) Turbine. Of these, only the first three are discussed, the others not being sufficiently developed.

A prime mover should be considered in regard to reliability, regulation, and cost, here arranged in their relative order of importance. The reliability of any machine depends upon proper design and proper operation. So far as design is concerned, all three types should be equally reliable. The steam turbine, owing to its small number of parts, small friction surface, and absence of reciprocating motion, should be extremely so, its one point of possible danger at present being the possibility of overheating high-speed bearings. The gas engine has overcome its earlier difficulties of design for parts having excessive pressures to withstand. The difficulty of ignition has been overcome by duplicate igniters and proper inspection, although the igniter will always be a source of trouble, and for this reason a practical gas turbine, or slow-burning type of engine will be sought for until it is found.

As to the question of proper operation, there is this to be said, that while but few have yet had experience with the gas engine, there is a small army of men who understand all the details of steam operations. An experienced steam engineer can tell by ear whether all is right or not with his engine; he knows a thousand makeshifts to help him out of tight places. Many of these will serve equally well with the gas engine, but more will have to be learned. The practical engineer cannot be taught in a day that clean gas is just as important as dry steam, and that cooling water is an absolute necessity in a gas engine, and not a mere help as it is in an engine-bearing. A gas engine installation is thoroughly reliable, but care should be exercised in the selection of the men, and they should not be left in entire charge of the engines until they are well educated. Many persons are claiming that a cheaper attendance will be possible with the gas engine. If by this they mean a smaller number of men, they are right, owing to the smaller number of auxiliaries; but if they mean less intelligent men they are mistaken.

It is more fair to consider the two plants rather than the engines alone. The steam plant consists of a boiler with a large number of joints under high pressure; a long line of piping under like pressure, and subject to extreme expansion strains, and a group of pumps, traps, condensers, valves, etc., with which it takes a man a long time to get acquainted. In the gas engine plant we have a producer and holder under little pressure; a low-pressure pipe line; no auxiliaries except a starting outfit and a very simple exhaust; a plant with

large possibilities for storage of power at low cost, and really so simple that in all gas engine discussions no attack has ever been made on any part of the plant except the engine.

Given proper operation, any one of the three types of plant is reliable and could be recommended for continuous service.

Regulation applies in two ways to prime movers: to speed of revolution, or simply "regulation," and to cyclical variation during a single revolution, or "variation." Steam engine contracts call for a regulation of 1.5 per cent and a maximum variation of 1¼ degrees in phase. Steam engines can regulate sufficiently well for the paralleling of alternators, the crucial test, as shown in daily practice. The steam turbine is capable of the very closest governing, and has in tests shown its superiority. The gas engine, receiving its energy not continuously, like the turbine, but in impulses, is more difficult to regulate.

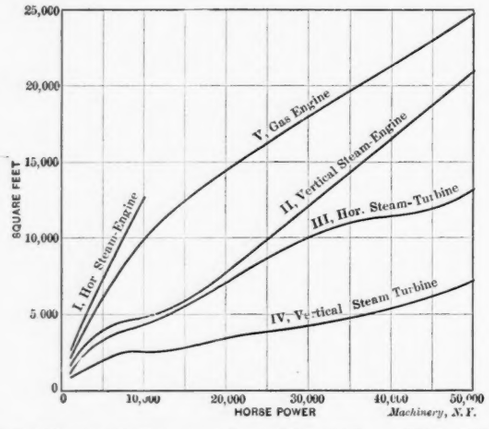


Fig. 1. Diagram of Floor-space Required for Different Kinds of Prime Movers, for Various Capacities of Plant.

There are four methods of gas engine governing, (1) the "hit or miss," (2) throttling, (3) impoverished charge, and (4) variation of explosion point. The first is unsatisfactory for large engines, and the third is but a modification of it, and is no more desirable. The fourth is uneconomical. Throttling, which does not have the objectionable features in gas engine as in steam engine work, will probably be the method generally adopted eventually.

In this country gas engines in large sizes have been built after three types: The three-cylinder single acting, four-cycle type, receiving energy two-thirds of every revolution; the two-cylinder single-acting two-cycle tandem type, receiving energy at every stroke, and the two-cylinder double-acting four-cycle tandem type, receiving energy at every stroke. Double engines are frequently built of the two latter types. An engine which receives energy as frequently as every two-thirds of a revolution can be governed well enough for any purpose, as has been shown in practice. Hence since the work is done satisfactorily by all three types, there is little room for argument on the score of regulation.

As to cost, it is of course impossible to approximate correctly in individual cases without special study of the conditions, but average figures can be given. Table I., herewith given, applies to the following plants: (1) A steam engine plant, consisting of a compound Corliss engine running condensing, without superheat, and supplied with steam by horizontal water-tube boilers with cast-steel headers; (2) a steam turbine plant under the same conditions; (3) a gas engine plant with horizontal gas engines and Taylor producers.

In discussing the various items, we come to consider relative amounts of space required for different types of plant. The curves here reproduced, as Fig. 1, are from a paper by E. H. Sniffen (Am. St. Ry. Assn. 1902). Curve III. is the Parsons steam turbine and curve IV. the Curtis. Curve V. is meant for the average gas engine.

A point to be considered in connection with this is that the boiler capacity is the same for engines and turbines, and the arrangement of boiler space, to go with the most economical spacing of the turbines, has to be considered. In Figs. 2, 3, and 4 is shown diagrammatically a plant of three 1,500 K. W. vertical turbines, with required boiler capacity, laid out in three different ways. Fig. 2 is the ordinary back-to-back method, which here is uneconomical unless the extra space is used for different purposes. In Fig. 3 the boilers are placed in two sections on the same level, and Fig. 4 shows a double decked arrangement. Engineers have seldom designed double

TABLE I. POWER PLANT COSTS.

First Cost, Dollars per Kilowatt.

	Steam Engine.	Steam Turbine.	Gas Engine.
Building and foundation	$12.00	$6.00	$10.00
Auxiliaries and piping	8.00	6.00	included in engine.
Engine and generator	32.00	30 00	74.00
Total	52.00	42.00	84.00
Boiler room or producer shed (including pumps, heaters, piping, economizer and stack)	12.00	12 00	included above
Boiler and stoker (erected)	14.00	14.00	20.00
Total	26.00	26.00	20 00
Grand total of first cost per kilowatt	78.00	68.00	104.00

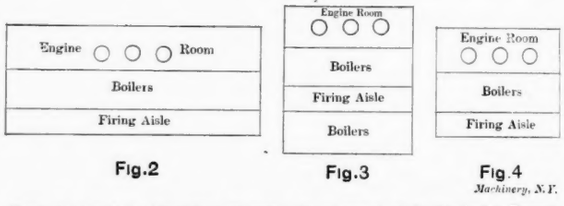
Operating Cost, Dollars per Kilowatt-year.

Fixed charges, 15% of cost	$11.70	$10.20	$15 60
Labor	6.20	5.75	4.40
Oil	1.50	.60	1.80
Coal	14.60	14.60	7 30
Total of operating cost per kilowatt per year	34.00	31.15	29 10

Notes: Capacity of each plant, 4,500 KW. in three 1,500-KW. units.
Interest, depreciation and taxes, 15%.
One year = 7,300 hours (365 days of 20 hours).
Load, electric railway of 50% load-factor.
Cost of coal, $2.25 per ton of 2,240 lbs.
Two engine H.P. = one boiler H.P.

decked boiler houses, but why in a turbine installation there should be any objection to them is hard to see. The risk from explosion is almost nothing with water-tube boilers, and the piping is very direct. The only difficulty, coal and ash-handling, is not a great one. Conditions are about the same with horizontal turbines.

A comparison of the space required for boilers and for producers shows some interesting facts. The amount of space



Figs. 2, 3 and 4. Sketches showing three ways of Arranging a Power Station using Vertical Steam Turbines.

assumed for boilers in the table is an average of that required for several makes of the water-tube type, though the most efficient make of this type known to the author requires only 1.28 square feet total floor space, and occupies only 26 cubic feet per boiler H. P. In Table II. is given a summary of floor space required by various producer plants. This shows an average value of 1.7 square feet per engine H. P., which is about the same as required by the boilers.

TABLE II. APPROXIMATE DIMENSIONS OF SPACE REQUIRED FOR PRODUCER AND HOLDER, FOR TAYLOR AND MOND GAS PRODUCER PLANTS.

Capacity.	Length. Taylor.	Length. Mond.	Width. Taylor-Mond.	Height. Taylor.	Height. Mond.
500 H.P.	42 ft	68 ft.	26 ft.	20 ft.	30 ft.
750 H.P.	45 ft.	70 ft.	28 ft.	25 ft.	35 ft.
1,000 H.P.	45 ft.	70 ft.	40 ft.	25 ft.	35 ft.
2,500 H.P.	50 ft.	80 ft.	80 ft.	25 ft	35 ft.
5,000 H.P.	50 ft.	90 ft.	155 ft.	25 ft.	40 ft.

As to the costs of engine and generator, the steam turbine should gain a little in the generator cost, owing to increased speed and reduction of weight. For years generator design has been governed by the demands of the Corliss engine. Most engineers hesitate about running this engine beyond 120 revolutions per minute. On the other hand turbo-generators run at speeds varying from 1,000 to 4,000 revolutions per minute.

The cost of gas engines is certainly excessive. Large en-

gines have been quoted at from $55 to $40 per H. P., f. o. b. works. This high cost is the only handicap the gas engine has at present; the loss here cuts down a large part of its gain in economy. The best steam engines of this size can be bought for about 7½ cents per pound. The gas engine gains, of course, in the absence of auxiliaries.

In the boiler room estimates are included all except coal storage and power handling. Power handling of coal will be found economical except in a few cases. As the capacity of the storage and conveyor plant need be only one-half for the gas plant what it is for the steam plant, there will be here a saving for the former. The figure quoted for the producer includes a conveyor to the top of the producers, and all auxiliaries necessary for delivery of gas to the engines.

As to operation and fixed charges, the latter are lumped at 15 per cent, being interest at 5 per cent, taxes at 2 per cent, and depreciation at 8 per cent. Depreciation on well-built gas engines should be about the same as for good steam engines. Depreciation on foundations should be figured the same as for the engines, as they are of no use after the engines have been removed. The gas plant gains in the labor item, on account of there being less coal to handle, and the absence of auxiliaries, etc. Our conditions are coal at 0.1 cent per pound, a year of 365 days of 20 hours each, and a 50 per cent load factor.

Coal consumption is assumed at 4 pounds per kilowatt hour for steam engines and turbines, and 2 pounds per kilowatt hour for gas engines. The best water rate the writer has seen recorded for a two-cylinder condensing engine with superheat is 10.17 pounds per I. H. P. or about 17 pounds per kilowatt hour. Nineteen pounds per kilowatt hour is, however, considered unusual and 25 pounds is probably average. So far the steam turbine has not done better, though whatever economy it has at the start it is likely to keep until it breaks down, since experience shows that there is nothing to wear except the bearing. It should be noted that the high values given above depend upon high vacuum, superheat, and very close attention. Theoretically, 27 inches of mercury is a very ordinary vacuum, but in a large number of stations that the writer has visited in the last few months the vacuum was seldom over 23 inches. The turbine seems to suffer more from poor vacuum than the steam engine.

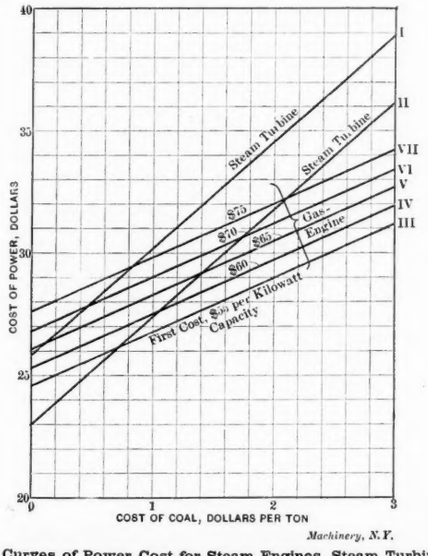


Fig. 5. Curves of Power Cost for Steam Engines, Steam Turbines, and Gas Engines, for Various Prices of Coal.

In the above estimates, using conservative figures, there is a yearly saving, per installed kilowatt, of $2.85 by the steam turbine and $4.90 by the gas engine over the steam engine. The writer believes that from now on the decision will usually lie between the steam turbine and the gas engine for all units. The simplicity of the steam turbine is really the source of its many advantages. One has only to stop and think of the hundred adjustments, places to wear, etc., of the reciprocating engine to realize this.

We formerly heard much about the greater economy in the use of steam by means of the steam turbine, but later experiments have shown these statements to be unwarranted. However, owing to the absence of valves and of lubrication on the steam surfaces, the use of superheat is very easy. Also, since there is no oil in the exhaust, the water may be used over and over. When necessary, the time for manufacture and erection can be made very small. Regulation can be made almost perfect.

The reasons for the slow adoption of the gas engine in this country are the newness of the field, the divided interest of many manufacturers who are also engine-builders, and third, the excessive first cost of the gas engine. As to the last, Fig. 5 is reproduced herewith, showing how changes in the value of coal and price of gas engines would affect the relative costs of power. Here ordinates represent cost of power in dollars per kilowatt year under the previous conditions. Curves III., IV., V., VI. and VII. are for the gas engine when the engine alone costs $55, $60, $65, $70, $75, respectively, per kilowatt of capacity. The points at which the gas engine curves cross the steam turbine curve show the minimum prices of coal for which the gas engine is as economical as the turbine. At present prices of engines coal must cost at least $2.15 per ton to justify installing gas engines on the score of economy.

In Europe the gas engine is regarded as entirely reliable, and is being used in all cases where it is economical. It is theoretically and practically much more efficient than any steam prime mover, the plant is remarkable for its simplicity and consequently the liability to shut-down is greatly reduced. The plant has great possibilities of power storage at little cost. The producer is probably 10 per cent. more efficient than the steam boiler, and even more so if the condensation losses in pipes, traps, etc., be included. Indeed, a poorer quality of coal might be used in the producer for results equal to those of the boiler.

DESTRUCTIVE ACTION OF INTERNAL TUBE CLEANERS.

The Locomotive, October, 1904, p. 90.

There are numerous forms of boiler-tube cleaners upon the market at the present time which are actuated by power. Some of these are designed to clean the inner surfaces of the tubes of water-tube boilers, some to remove sooty deposits from the fire side of the tubes of fire-tube boilers, and some to remove scale from the outer surfaces of the tubes of fire-tube boilers. These last act by striking a succession of blows against the interior of the tube, and thus jar the scale off from the outside. In the present article no reference will be made to those forms in which the deposits in fire-tubes are blown or sucked out by blasts of air or steam, nor to those by which the soot or scale is removed by the action of scrapers that are merely run through the tubes, except in so far as our remarks upon the danger of blowing steam through a cold boiler tube may be applicable to them. What is said will be mainly confined to those forms in which the apparatus employed communicates to the tube that is being cleaned a series of shocks of greater or less severity, either by directly hammering against the tube or the scale, or by the rapid rotation of a cutter or other revolving device which is corrugated or otherwise irregular in shape, and which strikes its blows in virtue of that irregular shape, the rotation, and the centrifugal force by which it is urged out against the tube.

The inspectors of the Hartford Steam Boiler Inspection and Insurance Company have made numerous reports of serious damage being done to boilers by cleaners of these types, and as the use of such cleaners is becoming increasingly common, the attention of steam users is called to the dangers that are incident to them, when they are improperly handled. These power cleaners are not condemned wholesale, because many of them give very good results when used judiciously and intelligently; but precautions must be taken in the use of such appliances, in order that the good results that they are capable of yielding may be realized, while the bad results may be avoided with corresponding certainty.

The reality of the danger from power tube cleaners is sufficiently illustrated by Figs. 1, 2, and 3, which are taken from actual specimens removed from a boiler upon which a power cleaner had been used. The particular cleaner that was em-

ployed in this case is one that hammers against the inside of the tube of a fire-tube boiler, the jar that is thereby communicated to the tube being supposed to rattle the scale off from the outside of the tube. In the instance now under discussion, two boilers of a certain plant had been cleaned in this way, and when they were again put in service seven of the tubes collapsed in one of the boilers when the pressure reached 90 pounds. The inspector of the Hartford Steam Boiler Inspection and Insurance Company was summoned at once, and upon visiting the plant he found that, in addition to the seven tubes which had collapsed, four others were strongly oval in shape, so that they had to be removed. Fig. 1 shows a portion of

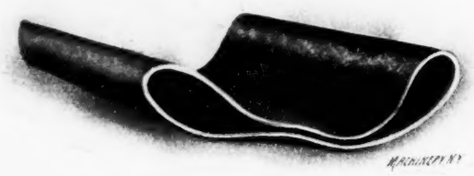


Fig. 1. Portion of Collapsed Tube.

one of the collapsed tubes, precisely as it was removed from the boiler; the flattened part extending to within nine inches of the end of the tube, or over the exact distance traversed by the cleaner. Fig. 2 is an engraving of a section of one of the other tubes, which had become oval from the action of the cleaner, but which had not collapsed. The cleaner, instead of being constantly rotated and moved along the length of the tube, had been allowed to remain in one position for a short time, so that the hammer had pounded against the tube in one spot, which is indicated by the bright area on the inside of the tube. The result was that the tube was forced out into an oval shape, the greatest bulge coming opposite the bright spot. The actual deformation of the tube not being very evident to the eye in Fig. 2, an outline cut is given in Fig. 3 that exhibits it more clearly. The black outline in this cut was derived by placing the section of tube shown in Fig. 2 endwise against a sheet of paper, and drawing its inner and outer contours with a pencil, the space between the two lines so obtained being then

Fig. 2. Section of Tube Deformed by Action of Cleaner.

filled in with ink, to represent the thickness of the tube. The actual, deformed contour being recorded in this way, dotted circles were next drawn, to show the original form from which the tube had been distorted by the action of the hammer. It is only fair to add that in this case micrometric measurements of the thickness of the affected tubes showed that they had been slightly thinned by the wear incident to ordinary use. The thinning was in no case great enough to render the tubes unserviceable, however, nor was it greater than would be found in the general run of boilers that have been a few years in service.

The cumulative effect of the blows of a power cleaner of this type, when the cleaner is permitted to remain stationary for a short time, is illustrated not only by the distortion of tubes, but also by their actual splitting, in severe cases. One inspector, for example, has recently reported a case in which three tubes were split in this way in one boiler, from a single application of the tool. In this case the affected tubes were previously in excellent condition, and not sensibly thinned by wear nor by corrosion. The continued and severe action of a power tube cleaner may also actually stretch the tubes longitudinally, so as to loosen them in the heads, and cause leakage and loss of holding power. In one instance, for example, an inspector found that a number of tubes in a boiler were projecting through the tube-sheet at one of the heads by as much as ⅛ inch to 3-16 inch, although they had been originally well beaded down to the head. As these tubes were in good condition at the previous inspection, and there was no visible reason for their elongation, the inspector made inquiries for the purpose of discovering the cause of the trouble, and learned from the engineer that a power tube cleaner had been passed through all of the tubes, and that the extension of the tubes had immediately followed its application.

These defects are not confined to cleaners which strike against the inner surfaces of the tubes of fire-tube boilers, but

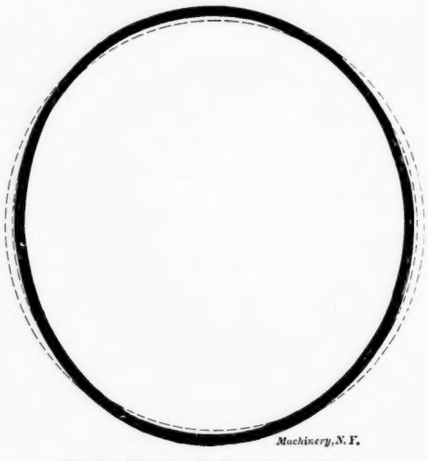


Fig. 3. Showing Deformation of Tube.

are liable to be observed in any type of power cleaner which operates by repeated concussion upon the tube, or upon such scale as may be attached to the tube. Numerous cases have been reported in which water-tube boilers have been badly damaged by the action of cleaners that have been run through their tubes for the purpose of cutting out the scale upon their inner surfaces. In one such report the inspector says: "They had worked on ten tubes in the bottom row of boiler No. 1, but they soon found that one of the headers was cracked, and upon examination it was discovered that every tube into which the cleaner had been passed had crept forward through the front head by from 1-32 inch to ¼ inch. I could hardly believe this, but I saw it with my own eyes, and know it to be a fact. The cracking of the header had been due to this cause, and I did not think that it would be safe to proceed any further with such an apparatus. I suggested to the management that possibly they did not understand how to operate the machine, and I emphasized to them the necessity of taking extreme care if they were proposing to continue its use, as it would never do to put such a stress upon these headers as they had evidently been subjected to."

In another case of a similar sort, where a water-tube boiler was being cleaned, "the cleaner was being used under a steam pressure of 100 pounds, and every blow of the hammer left its impression by a dent in the tube." In this instance the pressure used to operate the tool was undoubtedly very excessive. The pressure should certainly not exceed 50 pounds, and we are of the opinion that 20 pounds is all that ought to be employed. If steam of this tension is not directly available, a reducing valve should be employed, so that the actual pressure furnished to the tool could not exceed a reasonable limit, such as 20 or 30 pounds. Any tube that is scaled so badly that it cannot be cleaned by a pressure of this magnitude should be

removed and replaced by a new one. Leakage around the tube ends is a commonly-reported result of the use of mechanical cleaners, the tubes being either actually elongated by the blows, as already pointed out, or merely loosened in the heads or headers by the constant succession of shocks to which they are subjected. The extension of the metal is sometimes made evident by the sagging of the tubes, and one report tells of a case in which the tubes were so stretched that when the boiler was again put into service, certain of them bent up or down until they came in contact with tubes in adjoining rows.

In the case of cleaners whose action involves the discharge of steam into or through the tubes, leakage around the tube-ends, or the actual extension of the tubes through the heads or headers, is liable to be caused by the direct expansion of the tubes, due to the heating effect of the steam. If the tubes and the shell were all heated at the same time and by the same amount, there would be no stresses introduced by the heating; the danger being, not from the heat itself, but from the stresses caused by the fact that the expansion is local, and practically confined to the tube that is being cleaned. It is easy to see that if one tube grows longer from thermal expansion, while the rest of the boiler retains the dimensions that correspond to its lower temperature, there must be a stress of some magnitude thrown upon the tube and upon the heads or headers into which it is secured. The rise of temperature of a tube that is being cleaned by such a device is often considerable, for if a tube is at all foul with scale, it may require twenty minutes or so to bring it into proper condition. We believe that some (and perhaps all) of the manufacturers of tools of this kind, being alive to the danger of starting the tubes by local heating. recommend that the boiler itself be heated up, before setting the cleaner at work, so that the effects of the subsequent warming from the action of the cleaner may be minimized. This practice appears to be of doubtful wisdom. In the case of a water-tube boiler the only method of heating the boiler that appears to be at all feasible is to build a light fire under it, while it is dry. If the fire is handled carefully and by a man of good judgment, the boiler may perhaps be warmed in this way sufficiently to prevent subsequent injury from unequal expansion, and yet without being itself injured by the direct action of the fire; but we should hesitate to recommend such a measure for general employment, because we should fear that the average attendant could not be depended upon to always strike the somewhat nice medium at which the warming of the boiler is effective, while the boiler itself is not overheated in any part by the fire. Moreover, the remedy would hardly be effective in any case, unless the slow fire were maintained during the entire time that the tubes are being cleaned. If the boiler were heated up only at the outset, for example, then it is evident that if from ten to twenty minutes are spent upon each tube, the majority of the tubes in the boiler would have ample time to cool down before the cleaner reached them. If, on the other hand, the slow fire were maintained during the entire time of cleaning, there would be a correspondingly greater danger that at some part of this period the fire would either become so light as to be ineffective, or so heavy as to overheat some part of the boiler. It is far better and safer to avoid altogether the discharge of steam into a cold tube, and to operate the cleaner with compressed air. This is sometimes inconvenient, but it is better to go to a little trouble and expense, rather than to take chances of injuring the boilers. Of course it is unnecessary to say that there is no objection to the use of steam in those forms of power cleaners which are operated by motors external to the tube, and in which the exhaust does not enter the tube.

In review of what has been said, let it be stated that when power tube cleaners are used, they should be kept in motion, so that they cannot strike a succession of blows against any one part of the tube; 2, they should be operated by a pressure not exceeding 20 pounds, or, at the most, 30 pounds per square inch; 3, steam should not be permitted to blow through the tubes of a cold boiler for a sufficient time to sensibly heat the tubes; 4, compressed air should be used to operate tube cleaners, unless the motive power is entirely external to the tube; 5, in any case the boiler should be carefully watched during and after the application of a power cleaner, especially around the ends of the tubes, and on the headers; and at the first sign of distress of any kind, the use of the cleaner should be promptly discontinued; 6, lastly, a power cleaner should never be put in charge of any attendant save one upon whose judgment and skill the owner of the boiler can implicitly rely.

COST OF POWER IN STREET RAILWAY SERVICE.

Sibley Journal, December, 1904.

During the past twelve years the students of the graduating class of Cornell University have made a number of tests of street railway plants under the direction of Prof. R. C. Carpenter. Abstracts have been made of graduating theses describing these various plants, which are embodied in the shape of tables, as follows: Table I. Summary of Tests of Simple Non-Condensing Slide Valve Engines; Table II. Summary of Results of Tests of Simple Non-Condensing Corliss Engines; Table III. Summary of Results of Tests of Compound Non-Condensing Engines; Table IV. Summary of Tests of Compound Condensing Slide Valve Engines; Table V. Summary of Tests of Compound Condensing Corliss, Greene, McIntosh & Seymour and Similar Valve Motions; Table VI. Summary of Average Results; Table VII. Cost of a 1,000 Horse Power Plant (engines in units of 500 horse power each), and Table VIII. Fuel and Interest Charges for Different Classes of Engines per Horse Power.

TABLE VI. SUMMARY OF AVERAGE RESULTS.

Class of Engines.	Steam per I.H.P. pounds.	Coal per I.H.P. pounds.	Proportional Value of Engines.	Probable Coal per K.W.H. pounds.
(A) Non-condensing.				
Slide valve, simple; average.....	34.3	4.63	53.1	6.90
Best result	31.6	4.61	.....	.....
Corliss simple, average	28.3	3.45	64.5	5.65
Best result	26.9	3.01	.....	.....
Slide valve, compound, average..	30.37	4.17	60.2	6.12
(B) Condensing.				
Slide valve, compound, average..	22.7	3.25	80.5	4.57
Best result	16.7	2.40	.....	3.60
Corliss compound, average.....	18.2	2.36	100	3.64
Best result	14.5	1.80	.....	2.70

Tables VI. and VII. giving a summary of results and the cost of a 1,000-horse-power plant are reproduced herewith. In Table VI. a column appears giving the proportional value of the engine on the basis of coal consumption with a Corliss compound condensing engine placed at 100. A column giving the probable coal consumption per kilowatt-hour is also appended.

Cost of Various Plants.

The cost of engines, boilers, etc., varies somewhat with the supply and demand, and as prices of materials change. The prices given in Table VII. for engines are in accordance with bids which Prof. Carpenter has recently received for engines of approximately 500 horse power each. The price of water-tube boilers will vary with the kind selected, when erected on foundations, from about $10 to $16 per boiler horse power. For the sake of comparison he has assumed in Table VII. that the boiler costs $12 per boiler horse power.

Table VI. shows that the steam consumption varies for the different classes of engines tested, from 34.3 pounds per indicated horse power per hour to 14.5 pounds as the best results obtained, or to 18.2 pounds as the average result obtained with the best class of engines. From this it is evident that the capacity of boilers required for steam may be reduced as the quality of the engine is improved and this in a measure tends to equalize the cost of installation.

Table VII. does not include the expense of a relay boiler, which should generally be provided. The cost of electrical generator, switchboard and station wiring approximates at the present time very close to $22 per indicated horse power, or $33 per kilowatt.

No figures at the present time are available for steam tur-

bines in railway use, but the economy from the best figures obtainable would seem to be about the mean of the results obtained with the slide valve and Corliss compound. The present cost of a 400-kilowatt turbo-generator with switchboard, foundation and erection, very closely approximates $20,000.

The cost of power house and real estate varies largely with the conditions. The cost of chimneys varies from $2 to $5 per horse power, depending upon the character, as to whether steel or brick. The cost of economizer, which has not been considered previously, averages very nearly $5 per boiler horse power. To all estimates cited above an amount should be added for contingencies, which for safety should not be less than 10 per cent.

TABLE VII. COST OF 1000 H. P. PLANT—(ENGINES IN TWO UNITS OF 500 H. P. EACH.)

	Boiler H.P. required per Engine H. P.	Required Cost per Horse Power					Cost for 1000 H. P. Plant.
		Engine.	Boiler.	Pumps, Condensers and Heaters.	Piping and Foundations.	Total per I. H. P.	
Non-Condensing Engines.							
Simple slide valve.	1.135	$ 8.00	$13.60	$2.00	$6.00	$29.60	$29,600
Simple Corliss.....	0.933	12.00	11.20	2.00	6.50	31.70	31.700
Comp. slide valve .	1.00	11.00	12.00	2.00	7.00	32.00	32,000
Condensing Engines.							
Comp. slide valve.	0.75	11.00	9.00	4.00	7.50	31.50	31,500
Compound Corliss.	0.602	16.00	7.25	4.00	8.00	35.25	35,250

Table VIII. (not shown) is calculated for showing the yearly costs of operating power plants containing the different classes of engines. In this, interest is taken as 5 per cent and depreciation is assumed as 10 per cent. Fuel is calculated at $2 per ton, oil and waste are assumed to cost forty cents per year per horse power for each cylinder and each generator, an amount which experience has shown to be reasonable. Labor is calculated on the basis that a fireman is able to handle one ton of coal per hour and will work nine hours per day at a yearly cost of $600; when the coal exceeds one ton per hour by a small fraction an additional helper will be needed at an additional cost of $400 per year. The engine room force in all cases is assumed to be the same for all plants of 1,000 engine horse power, and is to consist of chief engineer at a salary of $1,200 per year, assistant engineer at a salary of $900 per year, and two oilers at a salary of $600 per year each, making a total cost of $3,300 for salaries in engine room. The wages for firing per year for 1,000 horse power, range from $3,200 (4 firemen, 2 helpers) for simple slide-valve non-condensing, down to $1,600 (2 firemen, 1 helper) for compound condensing Corliss of the best construction. The yearly fuel and interest charges per horse power range from $42.16 down to $23.20.

MANUFACTURE OF CHAIN.

The Iron Age, January 5, 1905.

Writing of the manufacture of chain, in *The Iron Age*, L. B. Powell calls attention to the importance of the chain-making industry, and the slight extent to which its processes are generally known. The manufacture of chain is divided into two classes: hand-made and machine-made.

A machine made chain covers sizes ranging from 3-16 to 1¼ inches, inclusive, and is made from open hearth steel in sizes up to 9-16 inch, and from ⅝ inch up is made from a common grade of iron. The principal steps in its manufacture are the winding of the links, cutting the links, and welding. The link-winding machine consists of a horizontal shaft about four feet long, driven by a belt and pulley attached at one end, while on the other end of the shaft is attached a mandrel over which the iron bar or steel stock is to be wound. The mandrel varies in size with that of the link to be formed, the outside dimensions of the mandrel being the inside dimensions of the link. Directly over the mandrel, and pressed tightly thereon by a powerful spring, is a steel guide wheel, grooved to carry the wire. The wire is fastened in the mandrel, the machine started, and the wire wound in a spiral of links, owing to the tight pressure of the guide wheel. When the spiral has reached the proper length, about 6 feet, the winder is stopped, and the spiral cut from the rest of the coil.

The spiral is next cut into links. This is done in a machine having a fixed blade for the base of the cutter, and a movable upper cutter, reciprocating up and down in a slide, being operated by belt and pulley. The spirals in being fed into the cutter are held in such a manner that the stock is cut at an angle of sixty degrees with the diameter of the rod. Each cut releases one link, the ends of which are cut scarfed, ready for closing. These links are now heated to a welding heat by either gas or coke fires, the former being the quicker and cheaper and the latter the more reliable. On being heated the links are linked into each other and the scarfed ends welded together by blows from a power hammer and taps from a hand hammer to give the material the proper working.

Hand-made chain is also known as "off the rod" chain and "dolly" chain. The iron for each link is cut off the rod and bent into shape hot, at the fire. After the weld is made, the joint is smoothed into shape by means of hammer blows on the dolly, which rests on the top of the link. The links are bent into shape on the anvil, and the ends scarfed by hand. For sizes of chain up to ⅞ inch, the chain-maker uses a kicker, which is a dolly hinged on the back of the anvil and having a treadle, so that it may be operated by foot pressure. All hand-made chain is made with coke fires.

Stud cable chain is a type of chain in which a cast iron stud, having its ends hollowed out to fit the sides of the link, is placed in the center of the link. The sides of the link are then narrowed to hold the stud firmly in place. This increases the tensile strength of the chain 50 per cent, and prevents its being bent out of shape.

Chains are tested on tensile testing machines in all chain manufacturing plants. Even when proved to be of the best material, however, the fibrous condition of the metal of a chain subjected to constant use and possible extremes of temperature is likely to change to a crystalline structure. This is known as the "tiring" of the metal, and is very dangerous. To obviate it, the chain should be annealed at least twice a year, by subjecting it to a uniform heat in a furnace, but never above a red heat. After remaining in the furnace for about four hours, at a red heat, the chain should be cooled gradually in a bath of sand. The chain should then be inspected for worn links, and given an oil bath.

The United States produces every year about 50,000 tons of chain, all for domestic consumption.

* * *

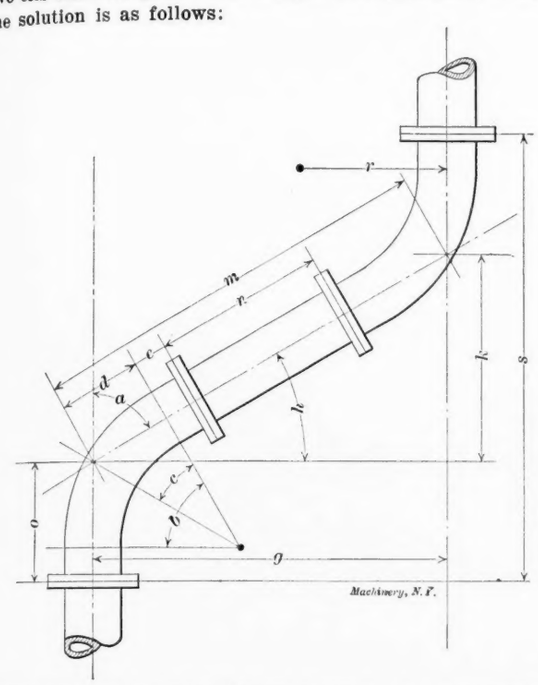
The United States consul general at Marseilles, France, says that notwithstanding official encouragement the alcohol motor and carbureter remains to-day incompletely developed, and the sale of alcohol motors is unimportant. Probably a hundred petroleum or gas motors are sold in France to one alcohol motor, and this he attributes to three reasons: 1, the high cost of alcohol; 2, the greater consumption per horse power hour than of either petroleum or gas; 3, the difficulties arising from oxidation. It appears from the report that the carbureter is not as efficient as an atomizer for the alcohol motor: a public competition with a 6-horse power motor showed the fuel consumed to be 0.904 pound per horse power hour with an atomizer as against 1.274 pounds per hour with the most popular carbureter in use in France. The trouble from oxidation which affects plugs, pistons, piston rings, etc., where alcohol is used, is serious unless care is taken to run the motor with gasoline during the last moments of use. It might be added that other experimenters have found a mixture of gasoline and alcohol to be more economical than the pure alcohol alone.

* * *

Errata: In the data sheet published with the January number, subject, Pipe and Pipe Threads—the decimal point was omitted in two of the formulas. For value of E read: E = perfect thread = $(4.8 + 0.8A)P$; and for height of thread read: Height of thread = $.8 \frac{1}{N}$.

METHOD OF FINDING DISTANCE BETWEEN TWO ELLS CONNECTING TWO PARALLEL LINES OF PIPE.

The article herewith was submitted to us by Mr. Franklin H. Smith, Niagara Falls, N. Y., who, having recently had a problem in piping to meet and solve, has sent us the results of his work in the hope that it may benefit others engaged in the same work. The problem was to find the distance between two ells connecting two lines of pipe running parallel, to which the solution is as follows:



Illustrating Method of Finding Distance between Two Ells Connecting two Parallel Lines of Pipe.

Referring to the sketch, the angle b = angle a = angle of given ell.

$$\text{Angle } c = \frac{b}{2}$$

d = radius r of the ell multiplied by constant for angle c for given ell, taken from Table I.

TABLE I. CONSTANTS FOR ANGLES c AND h.

Ell.	Constant—Angle h.	Constant—Angle c.
5 5/8°	10.15320	.04913
11 1/4°	5.02734	.09849
22 1/2°	2.41421	.19891
45°	1.00000	.41421
60°	.57735	.57735
90°	.00000	1.00000

e = distance to face of flange.

g = distance between centers of parallel lines of pipe.

Angle h = angle of 90 degrees minus angle a.

$k = g$ multiplied by constant for angle h, taken from Table I, for given ell. From whence

$m = \sqrt{K^2 + g^2}$. From whence

TABLE II.

Size of Pipe.	Allowance.	Size of Pipe.	Allowance.
1/2″	3/4″	3″	2 1/2″
3/4″	1″	4″	2 3/4″
1″	1 1/8″	4 1/2″	3″
1 1/4″	1 1/4″	5″	3 1/2″
1 1/2″	1 1/2″	6″	4″
2″	1 3/4″	7″	4 1/2″
2 1/2″	2 1/8″	8″	5 1/2″

$n = m - 2(d + e)$ = distance sought, or the distance between the faces of the flanges of the ells.

$o = d + e$ = distance from center of ell to face of flange.

$s = k + 2o$ = distance between faces of pipe flanges parallel to pipe line centers.

In practice the length, n, must be shortened enough to place a gasket at each end. If the pipe is threaded instead of flanged, twice the length of the enclosed threaded part on either end must be added to n. Lengths of the enclosed threaded part, or allowance, for different sizes of pipe are given in Table II.

* * *

THE THREE M'S.

The firm of Manning, Maxwell & Moore, familiarly known in the trade as the three M's, is a noteworthy one. Established in 1873 as H. S. Manning & Co., which title was changed in 1881 to Manning, Maxwell & Moore, the growth of the business has been steady and constant until it is now one of the largest of its kind in the world, with branches in Chicago, Cleveland, St. Louis, Pittsburg, Boston and Philadelphia; owning and controlling the Ashcroft Mfg. Co., Consolidated Safety Valve Co., Hayden & Derby Co., Hancock Inspirator Co. and the Shaw Electric Crane Co. On the death of Mr. Maxwell, one of the original partners, some years ago, his interest was taken up by his associates; and the occasion of this notice is the retirement of Mr. Henry S. Manning from the cares of business, and the sale of his interest in the firm and its allied companies

Charles A. Moore.

to Mr. Chas. A. Moore, the sale having been arranged entirely by the two men principally interested, after a partnership of thirty-two years, without taking an inventory.

Mr. Moore is one of the most widely known men in the machinery trade, but his acquaintance is not limited to that field, as he also has a wide interest in railway, social and political circles. President McKinley and Senator Hanna were among his personal friends, and it is said that the former offered him a position in the Cabinet at his first election. Mr. Moore is a man of strong individuality and great energy; and while credit should be given to Mr. Manning's business ability and to the almost unlimited financial backing of his associates, the success of the firm is largely due to Mr. Moore's individual efforts. He has many other interests and belongs to a large number of well-known business and social organizations.

* * *

A scheme that is sometimes used for locating pounds and knocks in high-speed engines is to rest a light stick of wood held between the teeth upon various parts of the engine, until the seat of the trouble is discovered. This, of course, only applies to the stationary parts, as there are very few who could wiggle their heads fast enough to follow the crosshead of the average engine!

THE AUTOMOBILE SHOW.

The annual Automobile Show held in Madison Square Garden, New York, from January 14 to 21 inclusive, was probably the most successful event of the kind that has been held in this country in the history of the automobile business, both in the matter of exhibits and the attendance. Large throngs of interested spectators were in attendance, and sales were heavy. A large number of machines, priced from $375 up to five figures were exhibited, and supplies and sundries in great variety. Although the majority of machines exhibited were purely for pleasure or racing, there was an appreciable gain in the number of motor trucks and delivery cars, showing that some builders are paying more serious attention to the utilitarian possibilities of the automobile. The main floor of the garden was crowded with cars mostly of the heavy tonneau type, and the basement exhibit was an extensive show in itself. The first and second galleries were occupied by the exhibitors of automobile supplies, speed devices, tires, wheels, speed changers, lamps, tools, and a thousand-and-one other things for which the trade has been found a good market. As an illustration of the variety we note among the exhibitors the Wm. Cramp & Sons Ship & Engine Building Co., who showed a line of manganese-bronze castings which has found considerable favor in the construction of automobiles. One of the striking castings exhibited by this concern was a 10-spoke manganese-bronze wheel center, the hub and spokes one casting and the spokes cored their entire length. Since this metal is guaranteed to have a tensile strength of 65,000 pounds per square inch, and an elastic limit of 30,000 pounds, it apparently has qualities which recommend it highly for the severe service to which it must be subjected in motor trucks and high-speed cars.

A number of novelties and speed-changing mechanisms were exhibited, one being the Shattuck device which was illustrated and described in MACHINERY, September, 1901. As will be remembered by those who saw this description, a gear cone is split longitudinally so that one-half can slide lengthwise upon the other half, thereby bringing the halves of adjacent gears in the same plane. The object of this movement is to change the meshing pinion from one step to the next without shock. However successful this device may be in actual use, the model worked very smoothly and attracted an interested crowd of spectators whenever it was shown in motion.

A number of the exhibitors showed chassis, that is, the frames, engines, and wheels, of their machines mounted over plate-glass mirrors, the reflection of which made the under side of the mechanism plainly visible from above. Some of these chassis were handsome specimens of work, the frames and all parts being polished steel with evidence of much hand work on the finish, but in many the complexity of mechanism would lead to the prediction that more or less trouble would be found in the care and operation. Perhaps the simplest machines of the tonneau type exhibited were the Northern automobiles. The engine is of the double opposed-cylinder type, the cylinders being mounted in a transverse inclined plane, and the crankshaft connected to the rear axle by bevel gears through an intermediate longitudinal shaft. This construction displaces the chain, and is finding favor with many automobile builders. It requires the use of universal couplings, and the result is that a variety of these interesting devices of variant and possibly of improved form were exhibited by manufacturers making them a specialty. Among the specialties were numerous oiling devices, some of the positive type which from a single reservoir distribute the oil to the various bearings of the engine. One of the inventions in this line is the Mason-Kipp valveless oil pump, in which the pistons or plungers are operated by eccentrics mounted on a shaft so that the eccentric twists or "wobbles" as it rotates, thus giving the piston a twisting and reciprocating action at the same time. In this way a longitudinal slot in the pump plunger covers and uncovers the opening leading to the delivery tube, and thus it acts as a valve as well as a piston. Perhaps as interesting an exhibit from a structural point of view as any was that of the Shelby Steel Tube Co., who showed a table top consisting of 3,500 pieces of their cold-drawn, seamless steel tubing set on end beneath a plate glass cover so as to show the cross sections. These sections of tubes are of great variety of shape—round, square, hexagon, oval, rectangular, etc.—and were arranged in an attractive geometrical design, which not only caught the eye, but gave a graphic idea of the variety of shapes in steel tubing now evolved for the constructor.

Several makes of speedometers were shown which indicate in direct readings the speed at which the machine is traveling. One of these, made by the Webb Company, is a geared rotary vacuum pump, which draws air against a vertical aluminum piston, weighing about six grains, and causes same to rise and indicate the reading on a vertical scale. As the piston rises, the chamber or cylinder enclosing it enlarges, being tapered with the large end up, which lets more and more air draw by it, thus putting it in balance for whatever speed the pump is driven at.

A freak, which, if it fulfills the promises of the inventor, should be popular in winter in those sections where snow is plentiful, is a motor sleigh. This machine propels itself by a kicking arrangement similar to that of a hay tedder. The inventor in defending his device from the aspersion of those inclined to ridicule, says that the average American citizen has a religious horror of being regarded as a crank, and it was this sort of spirit that drove Hiram Maxim, the inventor of the Maxim gun, to England. Whether or not he is entitled to rank with Maxim as an inventor, it appears that he has contributed to the amusement of the crowd, and for this much can be forgiven.

A novelty in tire-patching devices was shown in the shape of an unvulcanized patch of rubber, which is applied to a punctured inner tube with cement in the ordinary way. Being in the raw or unvulcanized state, it adheres more closely than treated rubber, and to make the patch permanent the inventor depends upon the heat generated in the tire to vulcanize the patch. As is well known, when running at considerable speed the tires of automobiles become appreciably warm or even hot, but whether the heat thus generated would be sufficient in all cases to vulcanize a patch to the inner tube seems somewhat doubtful. It certainly should not where speed regulations are enforced.

Many other schemes were shown, one being a horn which is blown with the exhaust by opening a by-pass valve with the foot; another scheme was a device for storing power to start the engine and save cranking. A spring is wound up by the engine while running and held by a clutch so that it may be released when the engine is to be started again; and so on. Surely the automobile industry is reaching large proportions, and the ultimate displacement of the horse seems nearer than ever before, although it is still so remote that it will be many years, we imagine, before he becomes so scarce in cities as to be a curiosity.

* * *

The Polytechnic Institute of Brooklyn has instituted a series of evening lectures for the members of its senior classes in Mechanical Engineering, this course to be open to outsiders upon payment of a small fee. Each lecture is two hours in length and will be illustrated by lantern slides and drawings. The following is a summary of the courses offered for the remainder of the year:

Eight lectures by William J. Baldwin, Consulting Professor of Thermal Engineering, on heating and ventilating systems in large buildings.

Six lectures by Reginald P. Bolton, Consulting Professor of Mechanical Installations, on mechanical installations in tall buildings.

Two lectures by Walter B. Snow, Consulting Professor of Aerodynamics, on mechanical draft.

Two lectures by H. H. Stock, Consulting Professor of Commercial Fuels, on coal.

Four lectures by Gardner T. Voorhees, Consulting Professor of Refrigeration, on refrigeration and cold storage.

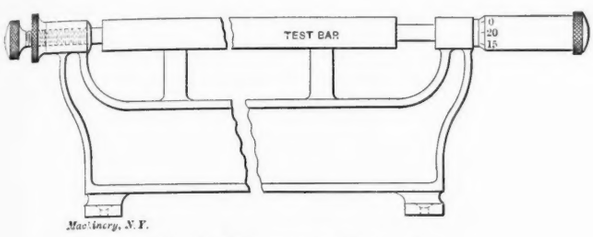
Similar courses are offered in Electrical and Civil Engineering, and if successful they will be continued and extended in subsequent years.

LETTERS UPON PRACTICAL SUBJECTS.

FOUNDRY MICROMETER FOR TEST BARS.

Editor MACHINERY:

A good deal is said and written at the present time about improved methods and tools in the machine shop—expensive and accurate gages are made and exhaustive tests are taken that the "brains" of the department may have the most complete data to work with, while in the foundry, where the raw material assumes a tangible form, little or no attention is given to the many details which would produce a greater uniformity of results. Not long ago in conversation with the foreman of a large foundry, this point was brought up and it seemed to the writer as if he (the foreman), expressed the sentiment pretty aptly when he said: "After all the available money had been spent for improvements in the machine shop, they would expect the foundry to rejoice that their equipment was so good and needs nothing new, and with the old equipment that had not even been honored by repairs for ages, help pay a dividend."



Foundry Micrometer for Test Bars.

Although, to the average foundry foreman, a micrometer is as much out of place in a foundry as gunpowder, it, nevertheless, has a use there; the foundryman's "hair" has the same limit of elasticity as the blacksmith's, and as experience teaches, can be stretched at will from 0.01 to 0.25 inch with impunity. But many a foundry foreman would appreciate any device that would tell him accurately and quickly the exact amount of shrinkage in a standard ½x½x12-inch test bar cast between chills, that would help to locate serious troubles with the work, and that would in any case furnish a set of data that would give an exact record of shrinkage from day to day, and in different periods of the heat.

The little device shown in the sketch was designed to accomplish this desired result, and as it is clearly illustrated, needs little description. The micrometer screw can be bought from hardware dealers, and the design can be changed to suit the individual taste of the designer. The bar rests on two parallel supports and at the rear of the bar two pins are inserted to keep the specimen parallel. As the bar is cast between chills, the faces presented to the anvil and measuring spindle are fairly smooth and would not produce any excessive wear. While a regular 12-inch micrometer could be used, or a caliper square, the gage as illustrated is designed primarily for the foundry and has the convenience of being, with the supports and device for holding the specimen, self-contained. Its cost is slight and its usefulness will appeal to the practical foundry foreman.

V. A. H.

"THE MAN WHO IS THE WHOLE THING."

Editor MACHINERY:

C. M. C. hit the nail on the head in his letter in the October number about the man who is the "whole thing." In the same slang I would like to know, "What are you going to do about it?" A great many men who are in authority are like the section boss, who always got to the car house at 7 o'clock. His regular greeting was, "Put on the cahrr. Good mornin', byes." One morning the men put on the car before the boss arrived. When he did come he swelled up with wrath and indignation. "Who towld yez to put on that cahrr. Take it right off. I'll show yez who's boss!" When they had the car back in the house, he said: "Put on the cahrr. Good mornin', byes."

The proprietor hires a man for foreman, but imagines people will think he is not much unless he shows that he is the "whole thing" himself. What is the foreman to do about it? Perhaps he is getting along in years or is so situated that he cannot very well leave town to hunt for another job. The foreman puts a man on a job; after a while he knows the job ought to be done and goes to see about it, but finds the job hardly started and the man nowhere to be seen. He asks a workman near by where John is. "Oh, the Old Man took him out a good while ago." Now tell me, what is the foreman to do? Perhaps he has promised that job by a certain hour and the time is nearly up. If he complains to the Old Man he will probably get "set down on" good and hard. The Old Man will show him who is boss. I see this almost every day of my life. When the Old Man is not there, the men play horse with the foreman and the Old Man complains that he cannot get a foreman who has any control over his men. Certainly not, though he pays well for it, too. When the Old Man goes out of town he leaves his dudish son in charge, and it is the son's ambition to make people think the business would be paralyzed were it not for him. He goes out in the shop and gives orders to the men, entirely ignoring the foreman. It makes the foreman feel like thirty cents. If some of the readers of MACHINERY can tell me what to do about it, they will greatly oblige a

FOREMAN.

MILLING FLOOR GRINDER BASES.

Editor MACHINERY:

Fig. 1 shows the base of a floor grinder strapped on the table of a No. 3 Cincinnati milling machine ready for milling off the caps and the rest shelves. The bases of these grinders (manufactured by a prominent eastern firm) were formerly planed in gangs of eight, each planer head taking a row of four. By this method the time required for planing to fit the caps and also planing the rest shelves was nearly two-and-a-half hours for each base, while they are now milled in less than one-and-a-quarter hour. Taking into consideration the difference in hour rates of a planer hand and a milling machine boy, the change of method caused a reduction of about seventy per cent in the cost of this operation. Although the

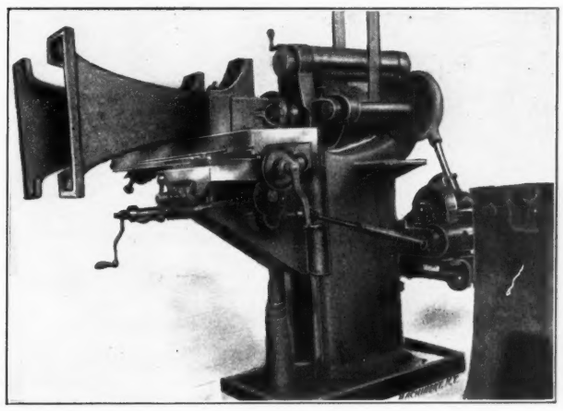


Fig. 1. Floor Grinder Base strapped on Milling Machine.

casting weighs upward of four hundred pounds, its construction is such that it needs no balancing when strapped to the milling table.

Fig. 2 shows a cross section through the milled part, and Fig. 3 gives an idea of the construction of the cutters. The larger cutter, used for various sizes of bases, is screwed onto the milling machine spindle, while the smaller one, which is slipped off and a new one put on when needed to fit the different requirements, is keyed to an arbor fitting the spindle taper. The cutters are made with cast-iron bodies and inserted teeth of high-speed steel, which, to allow for wear, are driven into slots, tapering at the bottom, as in Fig. 3. This allows the teeth to be driven forward and re-ground to correct dimensions both on face and outside diameter. The

cutters are run at a surface speed of 60 feet per minute, taking a cut ⅛ inch deep with a table travel of one inch per minute. Though this is rather slow for cast-iron milling, the

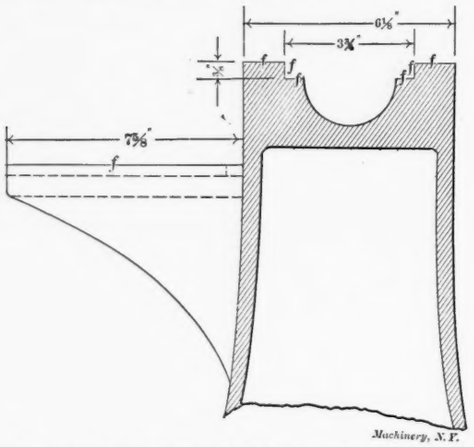


Fig. 2. Cross Section through Milled part of Floor Grinder Base.

cutters stand up so much better that the loss in speed is easily made to pay. J. C. SPENCE.

Worcester, Mass.

ON THE STRENGTH OF TIMBERS.

Editor MACHINERY:

The following discrepancy in relation to the strength of timbers has been called to the attention of the writer by an actual case of construction, and he would like an expression of opinion from some one competent to decide.

It is claimed that Kidwell's tables on the strength of timbers are the only tables known up to date which take into account the shear on the neutral axis of the beam; the author gives this shear as the limiting value for the supporting power of a beam for all spans up to twenty times the depth of the beam. He gives the safe value for shear parallel to the fiber for long-leaf yellow pine as 150 pounds per square inch, which is based upon a factor of safety of 4, the safe unit tension or compression resulting from flexure being given as 1,200 pounds per square inch, which is based upon a factor of 6.

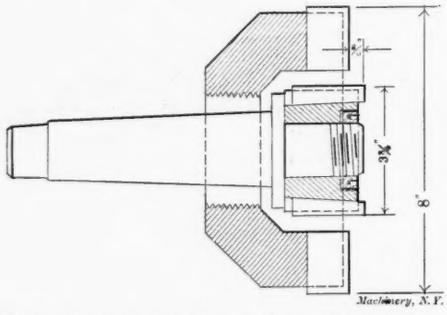


Fig. 3. Construction of Cutter for Milling Grinder Bases.

For 1,500 pounds per square inch working stress, he gives the supporting power of long-leaf yellow pine timbers, based upon shear at the neutral axis, about as follows:

Depth of Beam.	Spans up to	Total Safe Load per inch of Width.
6 inches	10 feet	600 pounds
8 inches	13 feet	800 pounds
10 inches	16 feet	1,000 pounds
12 inches	20 feet	1,200 pounds

Now from another authority—Applied Mechanics, by Gaetano Lanza, 7th edition, pages 319 to 321—the vertical shear on a rectangular beam = 2-3 bds, where b = breadth and d = depth of beam, and s = intensity of shear on the neutral axis. If we take s = 150 pounds per square inch for long-leaf yellow pine, as stated by Kidwell; then, vertical shear = 2/3 $bd150$ = $100bd$; letting b = 1 inch, vertical shear = 100 d; or for a timber 12 inches deep, the safe vertical shear would equal 100 × 12 = 1,200 pounds per inch of width; or if the load be a uniformly distributed or concentrated load in the center, in either of which cases the vertical shear is one-half the total load on the beam, the supporting power of the beam would be 2 × 1,200 = 2,400 pounds per inch of width instead of 1,200 pounds, as given in Kidwell's tables. In other words, a timber that I would figure to be a 6 × 12 inch should, by Kidwell's tables, be 12 × 12 inches.

Philadelphia, Pa. JOHN S. MYERS.

MACHINING A TEN-FOOT GEAR.

Editor MACHINERY:

In pursuing the following method of machining built-up gear wheels the idea was to overcome the liability to error, which invariably resulted when the parts were machined by the old method employed in this shop, and which caused no end of worry and delay when assembling the wheel. The specifications require that all parts be interchangeable, which is rarely the case by the old method, and the gain of time is of considerable moment. It is customary in machining built-up wheels of this type to first machine each segment of the rim at the ends *a*, Fig. 1, then bolt two segments together and plane the pad for spoke; these segments are then taken apart and the next segment bolted to one so as to plane the other end, etc. This method requires the time of bolting each segment and taking down after planing, and so on throughout the wheel; when assembling began some parts would be found wanting and others too long.

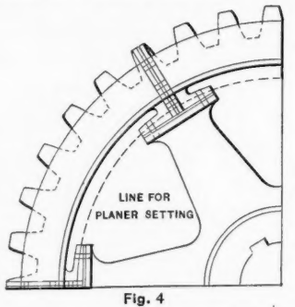


Fig. 4

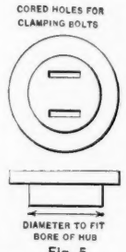
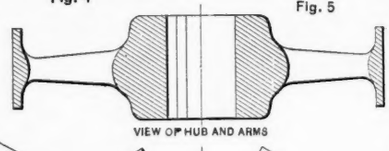


Fig. 5



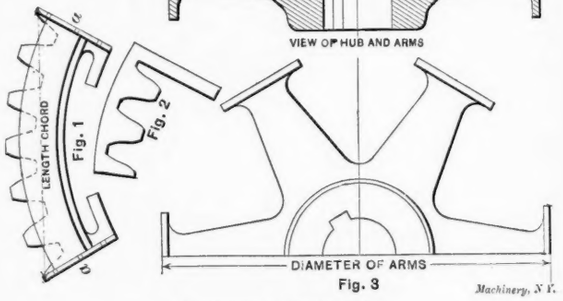


Fig. 3

Machining a Ten-foot Gear.

By the following process, however, these errors are obviated and the time reduced several hours on each operation. Each section of the rim is machined at each end, *a*, Fig. 1; a gage made of ⅜-inch pine, as shown at Fig. 2, is used for gaging the spaces. The chord of each sector being the same length, makes each interchangeable. These parts are then drilled and bolted together, completing the rim.

The next operation is to clamp the built-up rim on the boring mill table and face the shroud on one side and turn it to the pitch diameter; at the same setting the flat surfaces for the arm pads are bored back far enough to serve as a guide line and of a diameter to correspond with the diameter of the arms, Fig. 3. A line is scribed, as shown in Fig. 4, which is marked with a prick punch at each intersecting line where two sectors join. This line is for the convenience of the planer hand in bolting rim on the planer; hence its diameter is optional. A long, 5-foot angle-plate was clamped to the planer platen, and the rim bolted to the angle plate, with the faced side, having the prick punches, facing the housings. A surface gage measuring from top of rail to two prick punches diagonally opposite served to set in position for machining the five bored pads at one setting. By moving rail and setting

heads over the proper angles four pads were machined with down feed and the other with horizontal feed.

If all the arms are planed the same length from center of hub, which is readily done with the fixture shown in Fig. 5, no difficulty should be encountered in making the rim fit nicely over the ends of the arms. An allowance of 0.010 inch was found to make a nice fit.

GEO. L. RENNEISEN.

Louisville, Ky.

MAKING T-SLOT CUTTERS.

Editor MACHINERY:

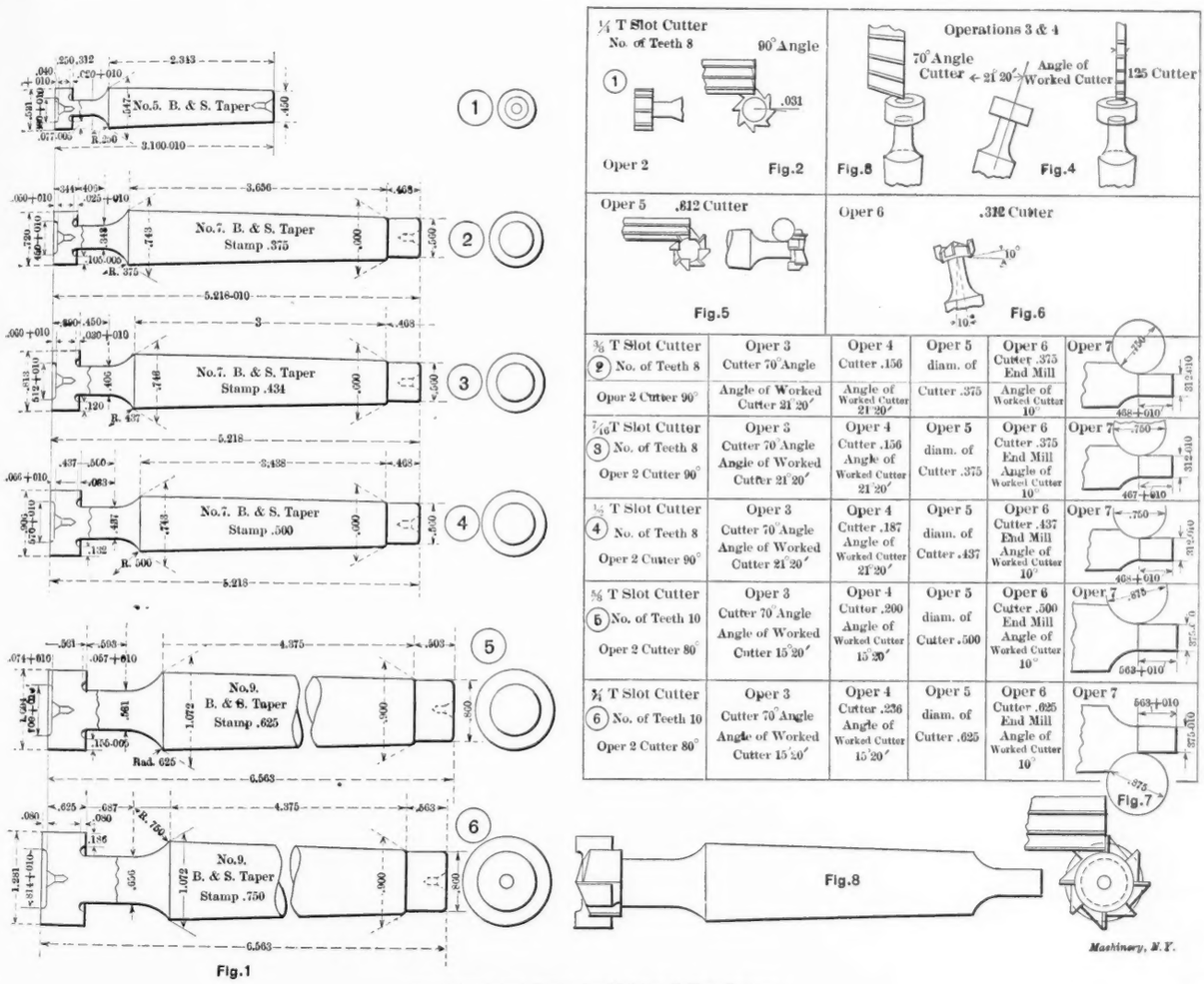
This type of cutter has gradually and successfully outclassed the old-style method of the planing T-slots in milling machine tables and other classes of machinery where T-slots are regularly used. It has not only outclassed the planer and shaper in the time required, but in the quality of the work done. With this in view, the writer has drawn out a series of operations and tools to assist those who may have this sort of tool to make. As will be seen from the drawings, the cutter is made completely by machining ready for the hardener. Where many are to be made it insures uniformity of each cutter throughout. In the first operation is shown the turning part or the lathe work necessary. In all cases where grinding has to be done add 0.010 inch; to the cutter part add 0.020, which is sufficient for that purpose. In the following operations we will take a ¼-inch cutter as an example:

The first operation, of course, is the turning. The second operation, shown in Fig. 2, is milling the teeth on the outside; an end mill of about ⅝-inch or ¾-inch is recommended. The number of teeth given is 8; angle of cutter required, in this case, 90 degrees. The third operation, as shown in Fig. 3, is milling the teeth on the face. In this operation the worked cutter, which is the cutter being made, should be placed at an angle of 21 deg. 20 min. from the vertical line, this angle being suitable also for the fourth operation. In the third operation, the working cutter required is an angle cutter of 70 degrees; while the worked cutter is in this position we commence the fourth operation, which is gashing every other tooth. It is an essential feature that clearance for chips should be considered in these cutters; the cutter required in this operation is an ordinary ⅛-inch slotting cutter. In operation No. 5 a similar gashing of the teeth takes place, but on the back instead of the front. The worked cutter is held in a horizontal position, and the working cutter is a 5-16-inch end mill. Operation No. 6 is the backing-off of the teeth at the back. The same working cutter can be used as in operation No. 5, the worked cutter being held in a vertical position at an angle of 10 degrees.

In the ¼-inch cutter no tongue is necessary, or is made. As will be seen in the tables below the illustrated operations, all above this size are made with a tongue on the end of the shank; therefore operation No. 7 gives the end mill required and sizes of the tongue. At the bottom of the series of operations is shown a complete cutter, Fig. 8.

J. LORD.

Birmingham, England.



⅜ T Slot Cutter (2) No. of Teeth 8 — Oper 2 Cutter 90°	Oper 3 Cutter 70° Angle — Angle of Worked Cutter 21°20′	Oper 4 Cutter .156 — Angle of Worked Cutter 21°20′	Oper 5 diam. of Cutter .375	Oper 6 Cutter .375 End Mill — Angle of Worked Cutter 10°	Oper 7
7/16 T Slot Cutter (3) No. of Teeth 8 — Oper 2 Cutter 90°	Oper 3 Cutter 70° Angle — Angle of Worked Cutter 21°20′	Oper 4 Cutter .156 — Angle of Worked Cutter 21°20′	Oper 5 diam. of Cutter .375	Oper 6 Cutter .375 End Mill — Angle of Worked Cutter 10°	Oper 7
½ T Slot Cutter (4) No. of Teeth 8 — Oper 2 Cutter 90°	Oper 3 Cutter 70° Angle — Angle of Worked Cutter 21°20′	Oper 4 Cutter .187 — Angle of Worked Cutter 21°20′	Oper 5 diam. of Cutter .437	Oper 6 Cutter .437 End Mill — Angle of Worked Cutter 10°	Oper 7
⅝ T Slot Cutter (5) No. of Teeth 10 — Oper 2 Cutter 80°	Oper 3 Cutter 70° Angle — Angle of Worked Cutter 15°20′	Oper 4 Cutter .200 — Angle of Worked Cutter 15°20′	Oper 5 diam. of Cutter .500	Oper 6 Cutter .500 End Mill — Angle of Worked Cutter 10°	Oper 7
¾ T Slot Cutter (6) No. of Teeth 10 — Oper 2 Cutter 80°	Oper 3 Cutter 70° Angle — Angle of Worked Cutter 15°20′	Oper 4 Cutter .236 — Angle of Worked Cutter 15°20′	Oper 5 diam. of Cutter .625	Oper 6 Cutter .625 End Mill — Angle of Worked Cutter 10°	Oper 7

Operations and Tools for Making T-Slot Cutters.

IMPROVISED VERTICAL MILLING MACHINE.

Editor MACHINERY:

For finishing plane surfaces, such as caps and bosses, especially in cast iron, the face mill used in the milling machine is by far the best tool, as it gives an accurate surface, smooth finish, and is two or even three times faster than other methods. The most convenient means of holding such pieces on the plain miller, in the vise or by bolts and straps, does not, however, give one much chance to use a face mill, and the spiral cutter, being more convenient as regards holding the work, is used in preference, but it is not as rapid as the face mill and perhaps is not as good as the planer or shaper. The

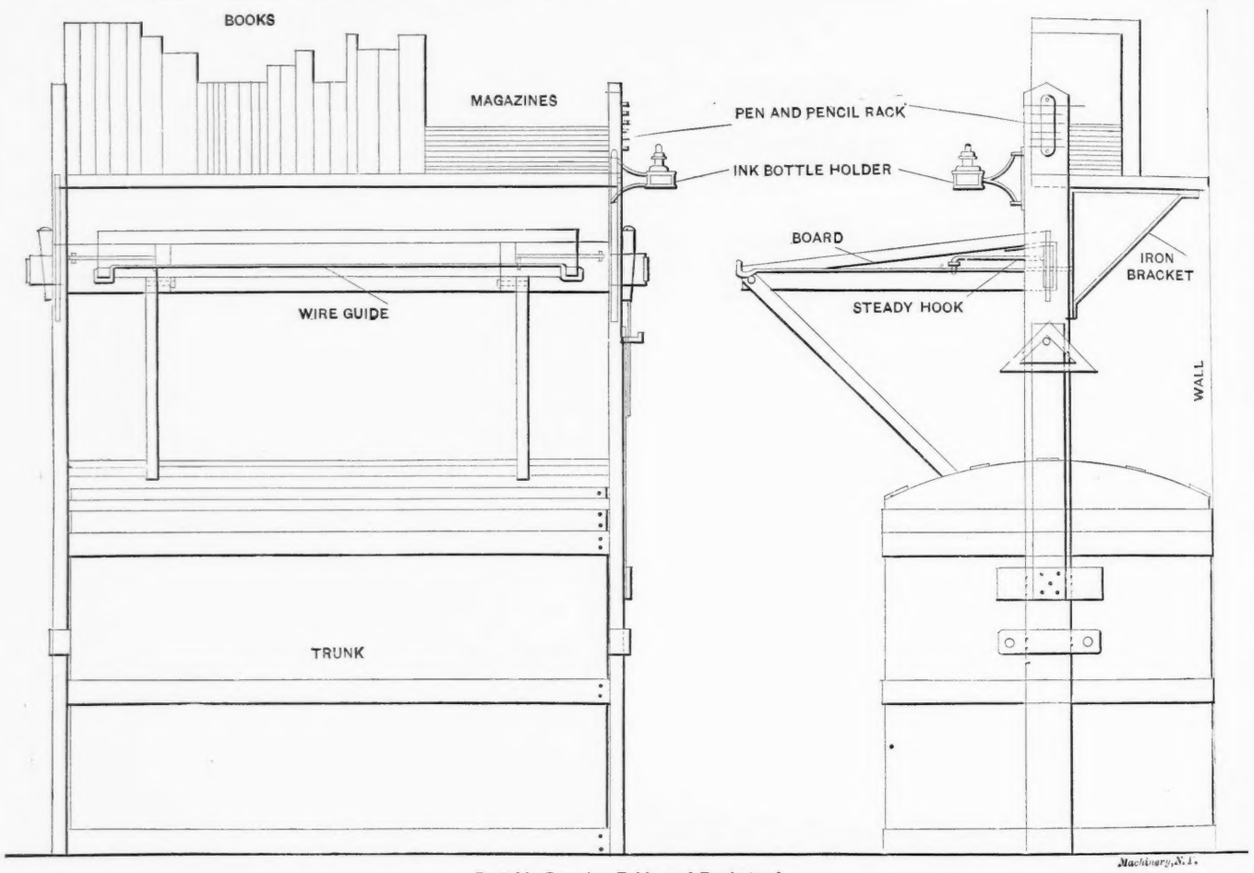
face mill, used in the vertical miller, is the ideal cutter, as it is rapid and accurate, and the pieces can be held conveniently while the cutting is in plain view.

Almost the same results can be obtained by placing an ordinary milling machine under a large upright drill; the driving pulley of the drill should be directly under the countershaft, and the drill should be swung at an angle, using a quarter-turn belt, or less, so that the drill spindle will be over the milling machine table. Belt the milling machine up in the usual way. Do not locate the drill spindle directly over the center of the table, and then two pieces can be worked on at once, if wished, by using a cutter on the milling arbor and a face mill held in the drill spindle. A special collet must be made for the drill spindle so it will use standard cutters, or an arbor with screw end provided to take standard face mills. In use the drill spindle is run down to the stop by the hand-wheel, and all backlash should be adjusted down to the finest point; fine adjustments vertically are obtained by the miller.

This arrangement does not handicap the milling machine for the ordinary range of work, while the vertical face mill feature will more than pay for the trouble of moving and setting up the machine.

CHARLES E. BURNS.

Boston Mass.



Portable Drawing Table and Bookstand.

DRAWING TABLE AND BOOKSTAND FOR TRAVELING MECHANICS.

Editor MACHINERY:

The cut shows a portable drawing table and bookstand, designed and made by myself. As I have found it very useful and handy, no doubt many another traveling mechanic may find it of use to him. It includes two uprights of such a width that they will fit tightly into the handles of the trunk in connection with which it is used. The height may be determined by the user according as to whether he may wish to stand or sit while at work. Between these uprights is a cross or tie-rail about one inch thick with a long tenon on each end, fitting into mortises in the uprights and held by wooden wedge keys. Secured to the back edge of the drawing board is a sheet metal strap, bent downward to hook over the tie-rail. The bracket arms supporting the board are held sideways by hooks screwed to the cross-rail and fitting into eyes screwed into the wood brackets. At the front end, as shown, are steadyrests which, resting on the trunk, help also to steady it the other way. I also threaded a wire at each end and put it through holes in the cross-rail, with a thumb-nut and washer on each side to hold the board sideways and prevent it from moving on the cross-rail. The peculiar shape in which the wire was bent can be seen in the cuts; it can be bent up a little higher in front to keep articles from sliding off the board if desired. At the back of the uprights iron brackets are screwed on, which support the shelf for books and magazines. The shelf can be extended and other shelves can be put on if desired. I made a swinging ink bottle holder of metal, and also attached to the uprights a pen and pencil holder, and a hook on which may be hung T-squares, triangles, etc. The whole is easily and cheaply made, and easily and quickly taken apart, folded for moving, and put together again. While it may not look so, it is quite firm and steady.

J. H. A.

SHOULD MACHINES BE BOLTED DOWN?

Editor MACHINERY:

Should machines be bolted down? This question is or should be often in the minds of engineers connected with machine tools. The only thing to be said in favor of the practice is that the floor or bed prepared for the machine takes part of the stresses and absorbs some of the vibration. The advantage in having a machine loose is that if the floor subsides or becomes much out of truth—and some floors are prone to this objectionable habit—it does not tend to strain the frame so much out of truth. Also the machine can be more easily removed. There are, of course, some few machines which, from the nature of their work, must be bolted down, either on account of excessive vibration, or because the character of the operation calls for a design which is "top heavy." The majority of machine tools engaged on ordinary work, however, could, and I think should, be designed with sufficient strength and rigidity to absorb all working stresses and vibrations without being bolted down. This applies especially to motor-driven tools, which from the ease of setting up driving connections should be more portable than belt-driven ones. A matter not irrelevant to this

subject is the position of the motor. One often sees it on or near the top of the machine, where, though appearances may be enhanced, it is not conducive to extra steadiness. It is better in most cases to extend the base and put the motor on it, though when in that position it need not look as much like an afterthought as it generally does. If the motor is not included in the framing, the vibrations are not so liable to be transmitted to the machine. As an instance of a fairly heavy tool which has been run permanently without being bolted down, I may mention a vertical miller weighing between 6 and 7 tons. This was leveled up with wooden wedges which extended all around the base, the wedges afterward being sawn even with the edge of the machine. We also run planers unbolted, sizes up to 3 x 3 feet being leveled up with wedges and larger sizes put on concrete. We have experienced no trouble with them up to the present; they do not move with the shock of the table reversal as perhaps would be expected, running as some of them do at 24 feet per minute cutting and 72 feet per minute return.

I should like to know if any of your readers have had trouble in setting up machines on wooden briquette floors, as I once had a fairly rough experience with one, the foundation being too loose. The tops of the briquettes were in anything but one plane, and unfortunately they sank unevenly even after we made them smooth on top. McANIC.

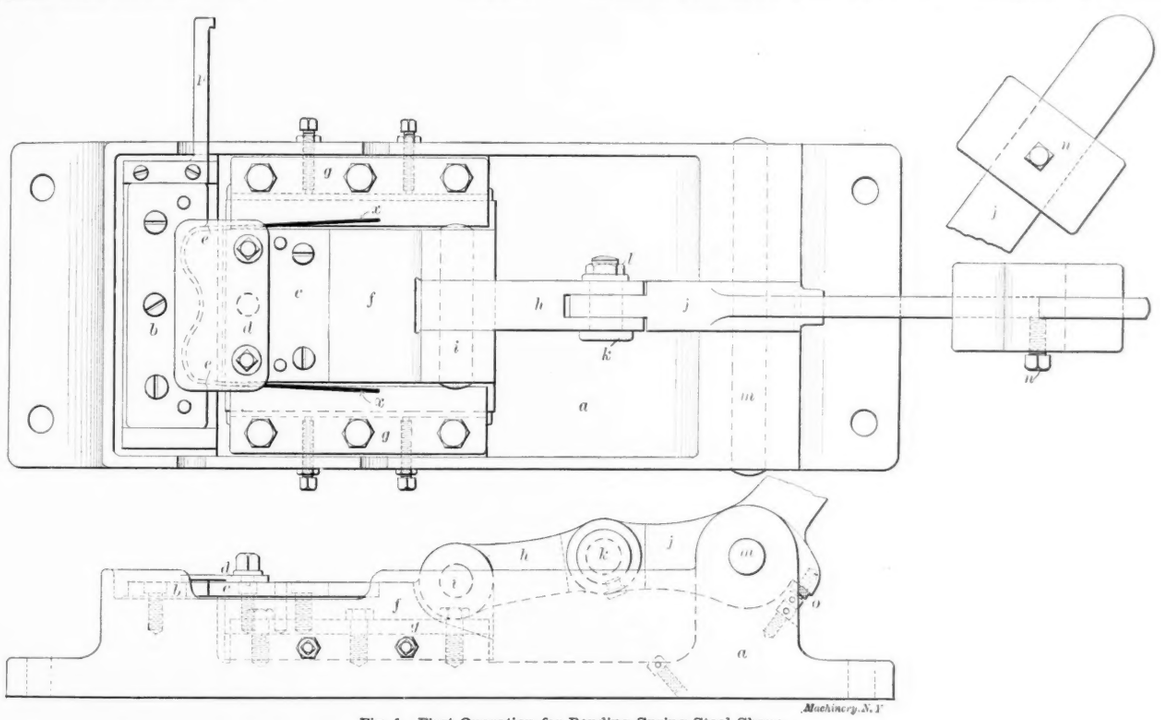


Fig. 1. First Operation for Bending Spring Steel Shape.

SET OF BENDING FIXTURES FOR TWO OPERATIONS.

Editor MACHINERY:

The bending fixtures shown herewith were designed for bending 7-16-inch by 3-32-inch spring steel to the shape shown at black line, *x*, Fig. 2, in two operations, with only one heating for each operation. The first operation is performed in the fixture shown in Fig. 1, the spring steel piece, *x*, being bent into the form indicated by the black and dotted line. It will be noticed that it is a hard, stiff bend, and one that requires powerful leverage to enable it to be done by hand. The bending must be uniform and exactly interchangeable to gage fit. The fixture was designed so as to accommodate different shapes in bending by exchanging the formers.

The frame, *a*, is of gray cast iron, made with a hole in each corner for belting solidly to the bench, with the handle at the right by the side of the operator. The frame is made with thin walls at the sides so as to form a pocket or reservoir for lard oil which is used on the formers when bending; with a brush in his left hand the operator brushes some oil across the face of the outside jaw before each bending operation. The steel must be heated very low, just hot enough so that the red can be discerned. The formers, *b* and *c*, are made of tool steel and are held in position with three screws and two dowel pins. The inside corners of *b* at *e e* are rounded so as not to cut the metal when it is forced into the former. Before making the formers it is necessary to ascertain the correct shape, as they must be such as to form the desired shape for the finished piece after it has been hardened. The shape can be calculated very closely by men accustomed to the work, or it can be found by trial, by using a few pairs of samples bent to the approximate shape, and trying one of each pair until one is found right after being hardened. The former is then shaped to the mate. The plate, *d*, held to the top of *c* by two screws, is for keeping the ends of the piece in alignment during the bending operation; at the same time it prevents the oil from flashing upward and burning the operator. The T-slide, *f*, carrying former, *c*, is made of cast iron and is finished all over. It is held down by two steel plates, *g*, which in turn are clamped with three screws on each side. Two steel gibs are provided on each side with gib screws and lock nuts to keep the slide in a central position, and to compensate for wear. At the rear end of the T-slide is a toggle joint consisting of the links *h* and *j*, and the bearing pins *i*, *k* and *m*. The pin, *i*, is made of tool steel and is a driving fit in the slide, *f*, and a turning fit in *h*. The screw *k* is drawn up solid to a shoulder with the nut *l*, and is a turning fit in *h* and *j*. The handle, *j*, swings on the pivot pin, *m*, which is made a driving fit in *j* and a turning fit in the frame casing. On the extreme end of the handle, *j*, is fastened a cast-iron weight or block, so as to be adjustable by loosening the screw, *n*. The block on the handle weighs 50 pounds, and this weight together with the toggle-joint action makes the machine very easy to operate, although a heavy pressure is required for the bending. To prevent drawing the metal too much, screw stops *o* are provided which limit the movement of the handle *j* in the forming operation. These screws are made of tool steel and are spring-tempered. Stops are also provided for limiting the withdrawal movement of the formers as indicated in the cut. The stop *p* is clamped to the fixture with two screws; and is used to locate the metal accurately before bending, so that each leg of *x* will be of the same length. The walls of the casing are cut away only sufficiently to allow the ends to pass over freely. The operator picks up the metal from the fire by tongs held in the left hand, and places it against the stop *p* and the face of the former. With the right hand he moves the handle *j* and the first movement of *d* locates the metal in

a horizontal plane, since there is only just enough room for it to pass over freely. The bending is done rapidly.

The second operation required for bending the ends around is performed in the fixture shown in Fig. 2. This fixture includes the frame casting *a* which has a hole in each corner for bolting it securely to a bench, with the clamping handle *d* on the opposite side from the operator. With a turn of this handle he clamps the piece *x* between *e* and *b*, and then with the right and left hands on the sliding handles *l l*, a simultaneous inward movement bends the legs of *x* around to the shape shown. In the center of the casing is the former *b* fastened securely by four screws and four pins. This former requires the same attention in design as the ones described in connection with Fig. 1; it is made in the same manner after having ascertained the right shape, of tool steel, tempered to a straw color. The tool steel sliding block *e* is fitted in a groove planed in the casing, and is provided with a suitable cap for holding it in position. It is tapped out in the center to fit the screw of the handle *d*. On its face it fits *b*, and both conform to the shape produced in the first bending operation. On each side of the casting *a* are planed two 45-degree dovetailed grooves which are provided with gibs and screws for adjustment. In these grooves slide the blocks *h*, carrying the roller holders *i*. These roller holders are free to swivel on the screws and each carries two small rollers, one of which rolls on the inside of the cam *c*, and the other bears against the piece *x* being bent. A flat spring on one side holds the roller holder continuously against the cam *c*. The rollers and holder are casehardened, made of machinery steel, as also is the cam *c*. The handles *l* are mounted on the sliding blocks *h* so as to move longitudinally, the holes for the screws being elongated for this purpose. C. O. P.

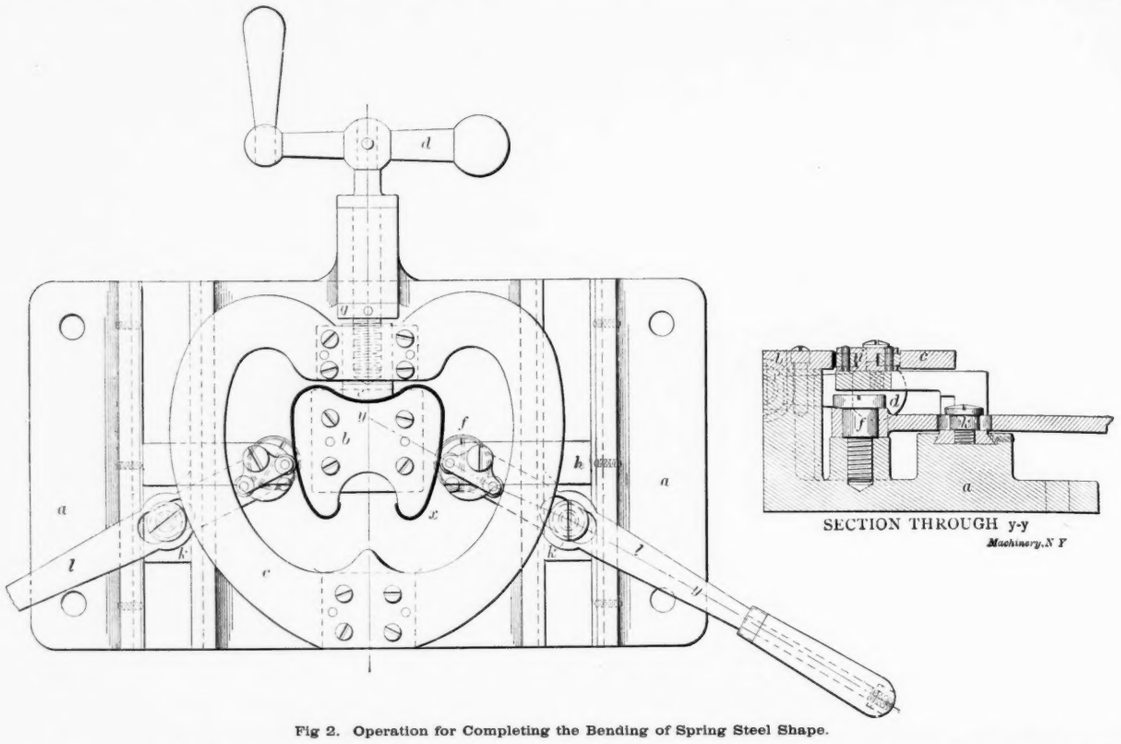


Fig 2. Operation for Completing the Bending of Spring Steel Shape.

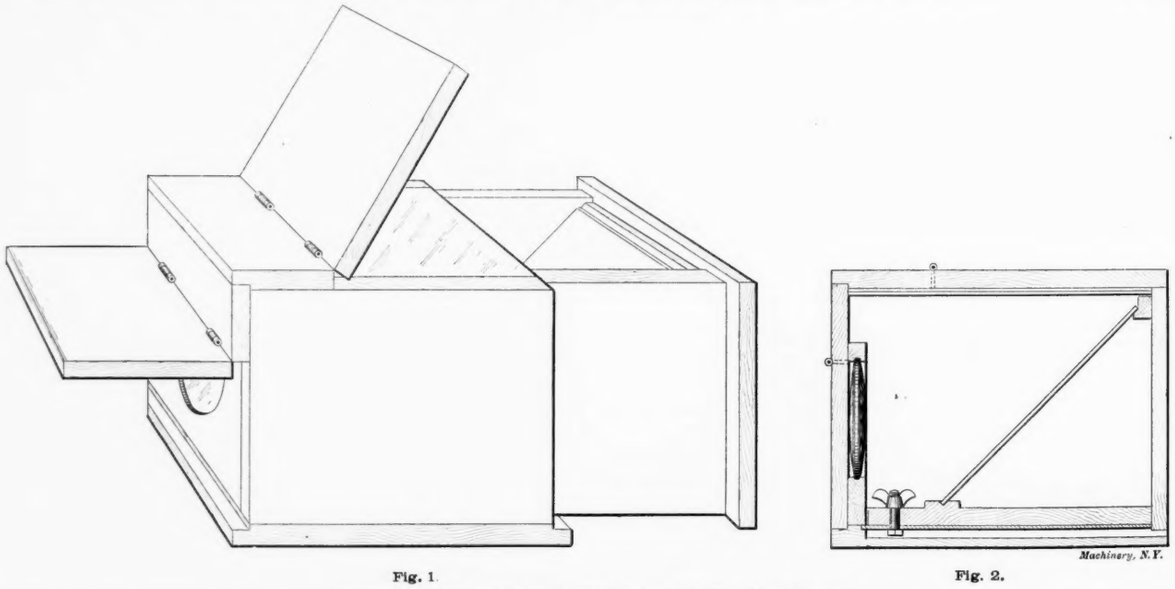


Fig. 1. Fig. 2.

Perspective View and Longitudinal Section of a Sketching Camera.

A SKETCHING CAMERA.

Editor MACHINERY:

To make free-hand sketches of machinery, or other similar objects, that are clear, well-proportioned and accurate in detail, is an accomplishment that requires an amount of skill, experience and artistic ability not commonly possessed; yet, such sketches are frequently of great importance, for reference and in designing additions and changes to existing structures. Recourse is often had to photography, but a photograph is not always readily obtainable; the light may not be right, and even

if a successful exposure is obtained, the developing of the plates, printing, toning and drying of negatives and other detail work take time, are somewhat expensive, and may not result satisfactorily; then, too, the surface of a print is not a good ground on which to put dimensions, etc., and such marks cannot possibly be made at the time of making the exposure. Draftsmen and others who may desire to make such views, with speed and accuracy, do not need to be told of the difficulties encountered, and some may be pleased to find a practical aid in an old, yet interesting, device, here shown, which is really a modified camera, known as a "camera obscura," sketching camera or mirrorgraph.

The whole apparatus is so simple that any one handy with tools can readily construct it; the first expense is the total expense, there being none consequent upon its use. A perspective view of the camera, with the slide partially withdrawn, and a longitudinal section, showing the interior arrangement, are given in Figs. 1 and 2 (previous page). A box, or frame, of thin wood, rectangular in shape, and of any convenient size, as say 10 inches long, by 8 wide and 7 inches high, is the foundation; it has a solid bottom, two plain sides, cover and front end, portions of each of which are free to swing on the hinges; the back end is entirely open; near the top, and along both inside edges are narrow strips for supporting the glass sketching surface; at the front, inside the hinged cover, is a frame to hold the lens. The slide has a base plate running the entire length inside the box; two triangular sides, and an upright back, which forms a part of the box when closed; from side to side, at the top and bottom, are cleats to support the mirror and in front of the bottom cleat, in the center of the base, are a bolt and thumb-nut for securing the slide to the base board, the latter being grooved, or T-slotted, for the head of the bolt to travel in.

All the interior parts should be finished in a dull—not glossy—black, so that the light rays may not be reflected. The cleats, on the slide, support a plain mirror, set at an angle of about 45 degrees; the exact angle can best be determined by experiment, as it depends somewhat on the length of the box and focus of the lens. A plain box, without the drawer feature, the mirror being stationary, can be used with fairly good results, but the arrangement shown allows a better focus to be obtained, or rather, the apparatus can be better adjusted as to distance from the object it is focused on. Directly above the mirror, and level with the top surface of the sides of the box, is placed a pane of ground glass; this can be covered, when not in use, by the hinged top as indicated; the latter, when raised, forms a shade on the drawing surface from rays of direct light.

The outside of the case may be finished as nicely as is desired, provided with trimmings, carrying straps, etc., to suit one's taste; it may be arranged to mount on a tripod, but the essential feature required is firmness—absolute—as, if it moves in the least, while making the sketch, the drawing is likely to be spoiled. The lens preferably used is a double-convex, of rather long focus, wide angle, and of comparatively large diameter, so as to admit a relatively large volume of light rays into the camera; an old reading, or magnifying glass answers the purpose completely.

When the camera is properly focused and secured, it will be found that an image of the object appears clearly on the ground glass, in all its natural colors, and will show through a sheet of tracing paper, placed on the glass, sufficiently well to admit of penciling it in. A perspective picture is easily obtained of the whole, or as much as may be desired, of the object, in far less time than by ordinary methods; any desired dimensions, or notes, can be added to the drawing at the time of making it and a very complete and satisfactory sketch results.

WARREN E. WILLIS.

Philadelphia, Pa.

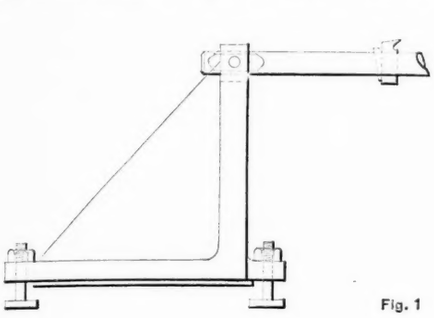


Fig. 1

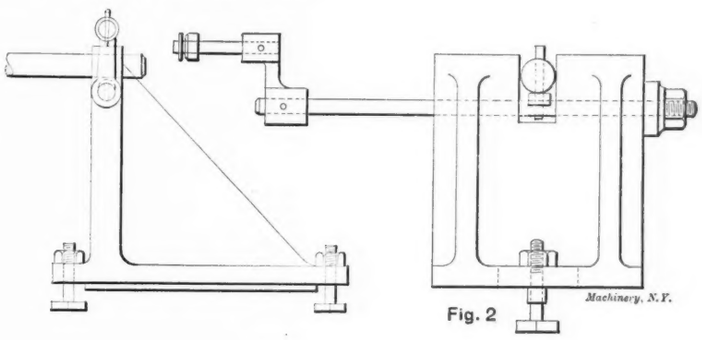


Fig. 2

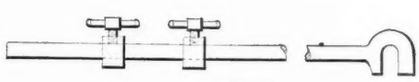


Fig. 3

Construction of a Keyseating Attachment for Planers.

KEYSEATING PLANER ATTACHMENT.

Editor MACHINERY:

The accompanying sketches illustrate a keyseating attachment, for planers, consisting of two very heavy angle pieces with heavy braces cast on the back, several bars, of sizes to suit holes of different diameters, and a faceplate or chuck which is fitted to the vertical slide in the place of the tool clapper. The bar, Fig. 1, is slightly flattened at one end, and a hole is drilled to receive a pin, which goes through the top of the angle piece, and hinges the bar to it. Near the center of this bar a slot is cut to receive the cutter, which is held in

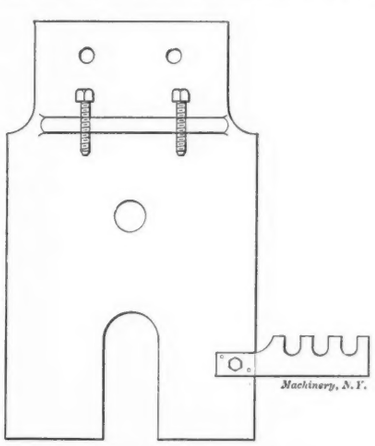


Fig. 4

Faceplate of Planer Attachment.

place by a taper key. The other end of the bar rests on a cam in the front angle piece, which is illustrated in Fig. 2. The rod, Fig. 3, fits on the crankpin and slides through one of the notches in the piece, which is bolted to the side of the faceplate. The set-collars can be adjusted so that when the planer is running, the crank will be moved enough at the end of each cutting stroke to move the cam from under the end of the bar, allowing it to drop sufficiently for the cutter to clear on the return stroke, at the end of which the other set-collar strikes and moves the cam under the bar again, ready for the next cut. The faceplate, Fig. 4, as stated above, takes the

place of the tool clapper, and the work is bolted to it, being fed to the tool by the regular vertical feed. There is a rib, or projection, near the top of this faceplate into which two or more setscrews are tapped to keep the work from slipping. Holes must be drilled or slots cored in the faceplate for bolting down the work.

It will at once be apparent to the practical mind that the range of work done by this attachment is limited, as to the diameter of pulleys, etc., but for keyseating flanges, or compression couplings, or slotting the ends of connecting rods, it will be found very powerful and rapid. C. P. L.

ACCURATE JIG MAKING.

Editor MACHINERY:

It was not my intention to ask for any more space in your columns on the subject of accurate jig making, but one sentence in the letter of Jig Maker, in the January issue, to the effect that the argument be carried to the end for the benefit of the younger readers, leads me to ask for your indulgence once more.

Jig Maker has come as an unexpected witness to the correctness of the method I have described, and I ask no better testimony than his, in corroboration of the position I have taken. He says he has knowledge of a factory in which the jigs used must deliver the finished product correct, to within 0.0001 inch. Now if this is so, and I believe it to be true, then it disposes once and for all of the claim that the drill is unreliable, for when work can be drilled to within 0.0001 inch, no greater accuracy can be desired. If drills can be used in that particular factory with such exact results, it follows that they can be used in other shops with the same results. Now when I make a jig upon the drill-press plan, I simply use a jig to make a jig, which I will prove by taking the reader through the process once more.

I will, however, first state that the first four chances of error that Mr. Shailor found and that Jig Maker seems to think are valid, would never be allowed to exist by any toolmaker competent to make an accurate jig. In other words, if he cannot eliminate these alleged chances of error, he could not make an accurate jig any way, no matter what method be used. The fifth chance for error (the possibility that the table of the drill press may be out of square with the spindle), may or may not exist. If it does, it, too, must as surely be removed for making the jig, as it just as surely had to be removed before the jigs, that Jig Maker has told us about, could deliver their work accurate to within 0.0001 inch. It is my opinion that the drill press that delivered such accurate work was very carefully examined to see that its table stood square with its spindle or spindles, and if it did not, it was made to do so before the work was proceeded with.

With these points disposed of I am up to the point of making my jig, that is to say, I have a drill press, holding a drill in its chuck, which fits the hole in a bushing, held by a bracket fastened to the frame of the drill press, and below is a table that stands square with the spindle of the drill. With this assurance, the next move is to prepare the table to receive the work. This is done by fastening two parallel strips to the table, by means of clamps, at any given distance desired from the bushing. The way to do this was described in the October, 1902, MACHINERY. One of the parallel clamps is fastened at right angles to the other.

Now, Jig Maker, I will take your jig that delivers us work correct to within 0.0001 inch, and using it upon another drill press that has been examined and corrected, will produce a piece of work from it, and at the same time duplicate it upon my drill-press plan. We will say that it has three holes in it, and they are spaced 1 inch apart from center to center. Now, I drill one hole in the work in your jig, and then I drill a hole in my jig plate, which I have previously placed as follows: The plate is laid upon the table, and the edge nearest to me is brought to rest against two round pieces of steel of equal diameter, say ¼ inch, and these in turn rest against the parallel strip, which of course must have a straight edge. The left-hand end of the plate is next brought to rest against a similar round piece of steel, and I am ready to drill. So far we stand upon equal ground with a hole drilled in the work in your jig and a hole drilled in the plate in my jig.

The second hole in the work in your jig is drilled by moving the jig along 1 inch, when it is ready for the drill; or, if a multiple spindle drill is used, simply bring the spindle down, or the table up, according to the type of machine. My second hole is obtained in this manner: The plate is moved along the table, and in place of the ¼-inch diameter steel piece that rested against the parallel on the left of the table, I use a steel gage that is 1¼ inches long, which is brought to rest against the parallel, and against which the plate is brought to bear. Now, if we have calipered the two pieces correctly, then the position of the plate has changed just 1 inch, and when the hole is drilled it will be just 1 inch from the other, measuring from center to center.

But, you say, that my drill is going to run out, and consequently the work will not be true; yours did not, it did its work true to 0.0001 inch, and I cannot understand why you think my drill is any more unreliable than yours. You also say that my gages may not be correct, that I may have given more or less pressure to one than to the other, yet you further state that you set the buttons on your plate, when making the jig, so accurately that the work from the jig is correct to within 0.0001 inch. If you can do this, others should be able to do as much, and it is no more difficult to caliper a short gage correctly than it is to set a button from two different edges of a plate.

To find the position of the third hole in my jig plate, I substitute for the 1¼-inch gage a gage that is 2¼ inches long, and proceed as before. When this hole is drilled it, too, will be just 1 inch from the second hole, and 2 inches from the first hole, for I have your word for it that work from jigs can be correct to within 0.0001 inch. Now, when I drill these holes I use a drill smaller than the hole is to be when it is ready for the bushing, and I do not drill it through the plate as I do not want to throw a burr up on the bottom of the plate. Just as other work from jigs is afterward operated upon, so will I operate upon my jig plate, and, if the work from your jig may be counterbored, reamed, tapped, recessed, etc., and still maintain its accuracy, so may my jig plate be further operated upon and keep its accuracy.

Mr. Jig Maker, when you have drilled a piece of work in a jig correct to within 0.0001 inch, and it is necessary in order to finish the piece to ream out one hole and counterbore another hole, do you bore the hole out before reaming, and do you find it necessary to chuck the piece to counterbore the other hole, to the end that the piece will interchange with some other piece of work that is also correct to within 0.0001 inch? I think not, and, if it is not necessary for you to do so, then why is it necessary for me?

The example of small jig making that Jig Maker has given is evidently an error. I think it should read .03 of an inch for the diameter of the gear instead of .3 of an inch. If so, it is indeed a very small piece of work; but, from the whole tenor of Jig Maker's letter, I am led to believe that he thinks that small work only requires great exactness, and very close measurements.

He asks your readers to seriously consider the drill-press plan of making the jig for this piece of work. I ask your readers to seriously consider the plan of making such a hole on an angle-plate of a milling machine; first setting the button correctly, next finding its position on the milling machine, then boring the hole out true, and next reaming it out. Just consider the difficulty of feeding the heavy table, table housing, and saddle against a boring tool that must enter a hole, perhaps less than 1-16 inch diameter, and that, too with the work in such a position that it cannot be seen by the operator. To my way of thinking it would seem a good deal like driving a very small tack with a 24-pound sledge hammer. If I had such a piece of work to do I would use the faceplate of a watch toolmaker's lathe, arranged in the manner I mentioned in the October, 1902, MACHINERY. It differs only from the drill-press plan in that it has no bushing to support the opening drill, and thus requires the hole to be bored out before it can be made to run true. All the center distances are obtained by gages as in the drill-press plan.

Jig Maker seems to think I was trying to work a "flim flam" when I stated the conditions under which a drill should be used to obtain a true hole. They were, first, that the drill should be started true. Surely Jig Maker should not expect a drill to run true that is started out of truth, and that drills used with bushings to start them do run true we have his word for. Second, that it will continue true if it is not crowded in the work. Jig Maker says this crowding occurs, but that it does is no excuse or reason for it. It is a fact that more hard work is put upon drills than any other tool used by machinists simply because, I suppose, they will stand it without breaking; if a boring tool was crowded in anything like the manner that drills are, it would be impossible to bore a hole true. Third, that the density of the metal be not changed by blowholes. Jig Maker says that blowholes are encountered, and the drill will thus change its path. It is my belief that when the jig was made that has been given us as an example by Jig Maker, it had no blowholes in it, or if it did, they were plugged up, or the casting, if a casting was used, was thrown away, which is exactly what should be done in any other similar case. Jig Maker says that in addition to the ten chances of error that Mr. Shailor found, he can name ten more, and, consequently, there is but one chance in twenty of my jig being correct. This, of course, applies to each hole, and if there are ten holes in the jig, then there is but one chance in two hundred of its being correct when finished. If this is true of the work from my jig, or rather the the system (which is, as I have stated before, but a jig), then it is also true of any other work that is made in a jig, and from these premises there can be no such thing as interchangeable work having holes, unless they are made with a corrected screw on a milling machine, or by the button method of locating the position of the work. We know, however, that work is made in jigs that is interchangeable with other work, and that, too, when it is done upon the despised drill press, and often in the hands of boys and girls, or other people of little mechanical knowledge, whereas, with my jig system the work is done by men who are supposed to be mechanics and to know when conditions are right or wrong.

Brooklyn, N. Y. J. R. GORDON.

BALL BEARINGS.

W. O. Renkin

Editor MACHINERY:

In the October issue of MACHINERY I notice a question, No. 11, referring to the carrying capacity of ball and roller bearings. I have had some experience with ball bearings, and as my results differ somewhat from those given in your answer, they may be of interest to your readers. Where the races are made as in Fig. 1, I find the following rule satisfactory for hardened steel balls of 1 inch or less in diameter:

Safe load in pounds = (diameter × 10)² × 31.

Example: For a ⅝-inch ball the safe load will equal (⅝ × 10)² × 31 = 39.0625 × 31 = 1,210 pounds. For a ¼, ½, ¾, and 1-inch ball, we find the safe loads to be:

¼-inch ball = 2.5 × 2.5 × 31 = 193¾ pounds.
½-inch ball = 5 × 5 × 31 = 775 pounds.
¾-inch ball = 7.5 × 7.5 × 31 = 1,743¾ pounds.
1-inch ball = 10 × 10 × 31 = 3,100 pounds.

This is considerably lower than if one-tenth of the breaking load is taken as the safe load, as given in your answer, the results there being as follows:

¼-inch ball = 6,000 × .10 = 600 pounds.
½-inch ball = 30,000 × .10 = 3,000 pounds.
¾-inch ball = 54,000 × .10 = 5,400 pounds.
1-inch ball = 77,000 × .10 = 7,700 pounds.

For balls greater than 1 inch in diameter, I find the safe load by using the formula (diameter × 10)³ × 26.5, though this is only for 1⅛, 1¼, 1½, and 1¾-inch balls, as I have had no experience with larger sizes. I find that in calculating it is advisable to add from 25 to 35 per cent to the total load on

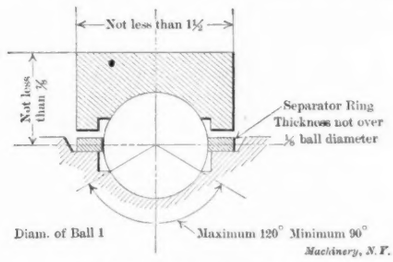


Fig. 1. Shape of Ball Races.

bearings, so as to reduce the wear and tear on both balls and races, which are always expensive. Moreover, in the case of step bearings or plates for vertical shafts, I generally use three less than the number of balls in the bearing for my calculation, for example:

For a step-bearing with twenty ¾-inch balls in one or more rows, take the total number of balls, say two rows of 20 each, equals 40 — 3 = 37; then, 37 × (diameter × 10)² × 31 =

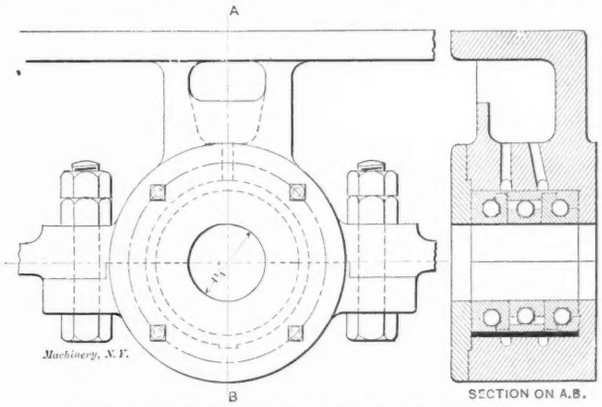


Fig. 2. Heavy Ball Bearing for Plate Glass Casting Table.

64,518.75 pounds = total safe load. Where a ball bearing is to be used as an axle or horizontal-shaft bearing, I take the total number of balls × 6 ÷ 19; thus, taking an axle bearing of three rows of ½-inch balls, with 12 balls in each row, we have: (3 × 12) × 6-19 = 11 7-19. Combining the whole number next lowest, in this case 11, with our formula, we have 11 × (0.5 × 10)² × 31 = 8,525 pounds as the safe load for this bearing.

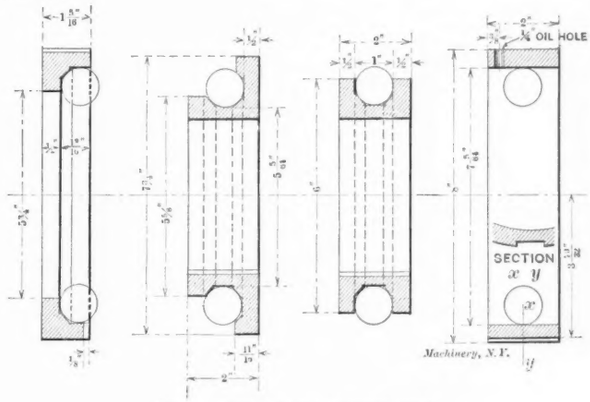


Fig. 3. Details of the Bearing Rings.

Figs. 2 and 3 show a heavy bearing we had built for a transfer table where we wanted a bearing that could be readily taken apart and examined, and one that would cause no wear either in the axle or in the bearing frame. The table is used in casting plate glass and is very heavy, being 18 feet 6 inches long and 11 feet 4 inches wide. The outer rings of the bear-

WILLIAM O. RENKIN, born at Allegheny, Pa., 1875, is now engineer in charge of the drawing office of the St. Louis Plate Glass Co. He took a special course in the Renkin Shops at Allegheny after completing a six years apprenticeship. Mr. Renkin has been employed by the Union Foundry Mach. Co., the H. C. Frick Coke Co., the Pittsburg Plate Glass Co., the Kittanning Plate Glass Co., and the Converse Transformer Co. He has had charge of selling and designing tooth gears, testing and building coal mining machinery and works, and designing and building a plate glass making plant; also large machines for high voltage power transmission.

ing are keyed to the bearing frame and the inner ones to the axle, and both being a slipping fit, when the table expands the bearings can slip out on the axle without disturbing the gage of the wheels. W. O. RENKIN.

Valley Park, Mo.

CUTTING MULTIPLE THREADS WITH A CHASER

Editor MACHINERY:

In regard to the article written by Mr. R. B. Casey, of Schenectady, N.Y., in the December, 1904, number, I cannot see how he could have cut a triple thread 3½ turns to the inch with a 10-thread chaser, and he did not say how the lathe was geared. If I had been doing it, I would have used a 10½-thread chaser and would have geared the lathe to cut 3½ threads per inch. A short time ago I had a similar job; it was a double 3½ thread which was to be cut so as to mesh with a 7-pitch single thread, the double thread, of course, running two to one. I geared the lathe to cut 3½ threads per inch, and used a 7-pitch chaser. A Reed lathe was used with a 6-pitch leadscrew, and the coarsest pitch thread on the index plate was 4 turns to the inch. The compound gears were 2 and 1, so I geared the lathe to cut 7 turns per inch, and reversed the compound gears, thus making it cut 3½ turns to the inch. Perhaps you or some of your readers can explain to me so I can understand how Mr. Casey did it.

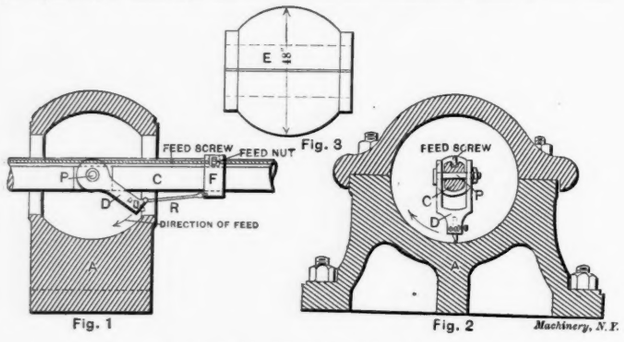
Providence, R. I. T. E. REMINGTON.

[A typographical error in Mr. Casey's letter made it read 3½ threads per inch, whereas it should have read 3 1-3, or 3-10 lead. This is obvious in the two following lines.—EDITOR.]

RADIAL ATTACHMENT FOR BORING BAR.

Editor MACHINERY:

The following method is, I think, as simple a one as could be devised for turning out spherical bearings in pedestals; it was used in building the engines for the Brooklyn Rapid Transit Co. In the accompanying cut *A* is the pedestal with a spherical bearing about 48 inches diameter, and *C* is the



Radial Attachment for Boring Bar.

boring bar, flattened a little on each side so that the atttachment, *D*, would have some side bearing when fitted on. Pin *P* was put through for the bar to swing on, as shown in Fig. 2. Two lugs were cast on the outer end of the arm *D*, from which connection was made to the collar *F*, Fig. 1, by rod *R*, and the whole device was driven by bar *C*, the collar being carried along by the feed screw. As the bar turns the movement of the feed screw causes the arm *D* and the cutting tool to traverse the arc of a circle; hence the combination of the two motions—feed and boring—bores the shape of a ball.

The bushing *E*, Fig. 3, was bored to size for the shaft, and then turned in the lathe. The toolpost was bolted to a swinging table, which was fastened to the bed of the lathe and pulled round by a spring belt attached to the carriage and driven by a feed screw. This was a simple and cheap arrangement, and by its use we made a very good job of both the bearings and bushings. D. LINDSAY.

Plainfield, N. J.

REGARDING ACCURACY OF JIGS.

Editor MACHINERY:

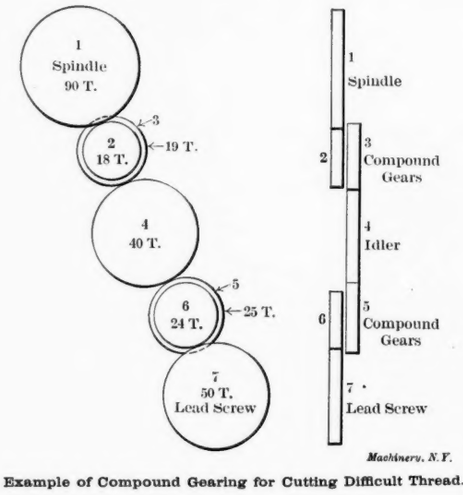
I wish to say a few words in regard to the controversy between Messrs. Shailor, Gordon and "Jig-Maker." No doubt each of these gentlemen considers his method of making jigs the correct one, and so it is on the class of work on which it may be used. It is a well-known fact, however, that undue accuracy and finish are very expensive and are to be avoided whenever possible, but in some manufacturing plants the greater degree of accuracy attained in the construction of the tools the easier it is to properly assemble the product. During my own experience I can say that I have made some very accurate tools, and then again I have made some that I would be ashamed to show to toolmakers like Messrs. Shailor and "Jig-Maker." But they have all accomplished their object, and that seems to me to be the prime consideration. If the young toolmaker will remember that the purpose of his daily toil is to enable his employer to earn profits he can readily judge for himself the amount of accuracy and finish required on a certain tool. I believe in the highest possible standard of accuracy consistent with an adequate return on the money invested, for it is in this way only that the toolmakers and other employes can hope for the material advancement which must come to them when the factory is managed on a paying basis. H. J. BACHMANN.

New York.

CUTTING ENGLISH-SYSTEM THREADS ON A METRIC LATHE.

Editor MACHINERY:

I frequently had some very difficult screw-cutting work while working some years ago in a machine shop in Paris, France. Our worst troubles arose from having to cut English-system pitch screws on a metric lathe having a leadscrew of 10 millimeters lead. On one occasion two days were spent by the foreman and one of the oldest lathe hands in trying to find change of gears to cut a certain pitch, calculation having been given up. But the job, a brass nut 5 inches long with triple thread to fit a screw, was pressing and something had to be done. I was finally called upon to solve the problem.



Example of Compound Gearing for Cutting Difficult Thread.

Taking stock of the change gears with the lathe, I found all gears from 18 to 26 teeth inclusive; 28, 30 and 35, and from that up to 120 varying by five teeth each. I am not sure of the exact pitch of the screw, but believe it was 23-32 inch, or 18.253 millimeters. I remember that with three regular gears I could cut a screw which varied from that desired 0.010 inch in one revolution, the pitch being too slow. I then figured on introducing compound gears, which would enable us to cut the required lead. Two new studs were made for compounding and on one 18- and 19-tooth gears were placed, and on the other 24- and 25-tooth gears. The 18-tooth gear was meshed with the lathe spindle gear, and the 19-tooth gear with an idler which drove the 25- and 24-tooth gears on the second stud. The latter gear meshed with the change gear on the leadscrew. I have found this arrangement very useful for cutting any odd pitch screw, that is inserting compound gears to suit the case. EUGENE WOPALETZKY.

Trenton, N. J.

SHOP RECEIPTS AND FORMULAS.

Practical Tried Receipts—those known to be Good—are Solicited.

CEMENT FOR SLICKING LEATHER FILLET ON BRASS PATTERNS.

Melt together 8 parts pure beeswax and 2 parts rosin; cut into strips when cold and apply with a slicking tool of the proper radius. A piece of wire set into a steel ball, and heated over a Bunsen burner is the best for this purpose. The pattern should be slightly warmed to enable the cement to flow between the leather and brass. When cold any superfluous cement may be removed with a piece of waste soaked in spirits of turpentine.

H. J. BACHMANN.

New York.

TO MOTTLE CASEHARDENED PIECES.

A simple and effective way to get a mottled effect in casehardening with cyanide of potassium is as follows: Set an open pail or jar under a running hydrant, get the pieces good and hot (bright red) in a ladle of molten cyanide, then take out singly with tweezers and simply throw them into the water. The air bubbles rising through the water give the desired mottled effect. A still better process, if an air blast is at hand, is to connect a rubber hose in some manner to the bottom of the pail, so that a stream of air enters the water. This plan serves well where no special appliance is available for this class of work.

HARRY ASH.

Chicago, Ill.

TO COAT ZINC SHEET BLACK FOR TEMPLET WORK.

In answer to question No. 16 in the December issue of MACHINERY for a receipt for coating zinc or tin sheets black for templet work, I send the following, taken from Brown & Sharpe's book on gearing, page 85:

"Dissolve 1 ounce of sulphate of copper (blue vitriol) in about 4 ounces of water, and add about one-half teaspoonful of nitric acid. Apply a thin coating with a piece of waste."

Chattanooga, Tenn. ALEX. C. LABAR.

FILLER FOR DEFECTIVE CASTINGS.

I herewith give you a formula for filling defects and blow holes in castings. I have been using this receipt for years and it is the result of many experiments: 1½ parts litharge, 2½ parts dextrine; 4 parts iron borings or turnings carefully sifted. Mix the parts well, add water until the mass is of about the consistency of mortar. With a putty knife or other instrument fill the defective parts and press into every crevice. Let it "set" for 48 hours, when it can be chipped, planed, bored, or turned like the casting itself. Color with lampblack to suit shade of casting.

To facilitate the measuring of parts, use a box of three divisions, made to the following dimensions: The division for borings should be 4 inches long, 2 inches wide, 1 inch deep; for dextrine, 4 inches long, 1¼ wide, 1 inch deep; for litharge 4 inches long, ¾ inch wide, 1 inch deep.

York, Pa. W. W. BIRNSTOCK.

* * *

HOW AND WHY.

A DEPARTMENT INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST.

Give all details and name and address. The latter are for our own convenience and will not be published.

The following questions are referred to the readers:

27. C. K. Will you kindly inform me of any prescription for thinning lard oil after it has gotten thick from use.

28. W. C. W. How are the wire handles made that are used on stove doors, pokers, lid-lifters, etc? They are wound of spring wire, small at each end and large in the center to fit the hand.

29. H. T. M. Does the "angle of pressure" of spur gears cut with the Brown & Sharpe cutters alter when the number of teeth falls below 30?

A. The angle of pressure should remain constant in all involute tooth systems, and with the Brown & Sharpe system it is 75½ degrees throughout the range from a 12-tooth pinion to a rack. In an interchangeable system like this where high and low-numbered gears are likely to work together, it is necessary to round off the points of the teeth, to avoid interference, which also applies to the rack tooth, but this rounding off does not change the angle of pressure. With worm gears, however, it is desirable to retain a straight-sided tooth in the worm, but below 30 teeth a straight-sided tooth causes undercutting of the wormwheel. To avoid this, the angle of the worm thread is sometimes changed. The rule given in "Formulas in Gearing" is:

$$\cos \gamma = \sqrt{1 - \frac{2}{N}}$$

2γ = angle of worm thread,

N = number of teeth in wormwheel.

Using this formula, the included angle of worm thread for a 17-tooth wormwheel, for example, is found to be 40 degrees, nearly. Some manufacturers believe that this angle should have been adopted for the involute tooth system instead of the one now generally used.

30. H. P. R. Having been laid up a few days with a sore eye, caused by a particle of emery wheel grit, I wish to ask: 1. What is the best way to avoid the sparks from an emery wheel when tool grinding? 2. What strength of cocaine should be used to render the eye insensitive when removing grit imbedded therein? 3. What is a simple remedy for inflammation.

A.—When an emery wheel sparks and throws grit badly it is evidence that it is not adapted to the work, or is in need of truing up with the dresser. When a wheel is in good condition the greater part of the debris will be thrown directly down from the work, and little will fly from the wheel above the tool. When using an emery wheel the operator should always stand, if possible, to one side of the plane of rotation. In this position he will avoid flying particles and the more serious danger of flying fragments in case the wheel bursts. 2. Druggists recommend a cocaine solution of from one to two per cent strength for eye work, but it should be employed very cautiously, and we should, in general, advise against its use by the inexperienced. 3. Salt water applied with an eye glass or cup during the day, and soaked in absorbent cotton and bound over the eye at night, is perhaps the simplest and best remedy for inflammation, caused by foreign substances; it has the merit of being harmless in any case, which cannot be said of some eye lotions.

31. P. J. M. A regular lathe leadscrew is 3⅜ inches diameter over the top of the thread and 2 7-16 inches diameter at the root, and the lead is 1 inch; what would be the length of six turns of the thread if they were unwound and straightened?

A. Theoretically, your proposition is impossible since the moment we attempt to straighten a helical coil, it is distorted and loses its identity; in other words helical surfaces cannot be projected on a plane. Practically, however, the metal represented in the top of the thread would be compressed and that at the root, stretched, the relative amount of compression and stretch depending upon the metal and the position of the neutral axis, which latter in turn depends upon the shape of the thread section. For an approximately square or rectangular section this would coincide with the middle axis. Therefore, for the sake of simplicity it will be assumed that the length of the thread when unwound would equal the length of the helix located midway between the top and root of the thread. The length of this helix is found as follows: The depth of the thread groove is 3⅜ — 2 7-16 ÷ 2 = 15-32 inch, hence the mean diameter of the thread section is 2 7-16 + 15-32 = 2 29-32 inches, and the mean circumference is 2 29-32 × 3.1416 = 9.13 inches. The circumference and lead of thread elements correspond to the two sides of a right-angled triangle, and the helix corresponds to the hypotenuse. Hence $\sqrt{9.13^2 + 1^2}$ = 9.185 inches, length of one turn, and the length of six turns would be 9.185 × 6 = 55.11 inches.

* * *

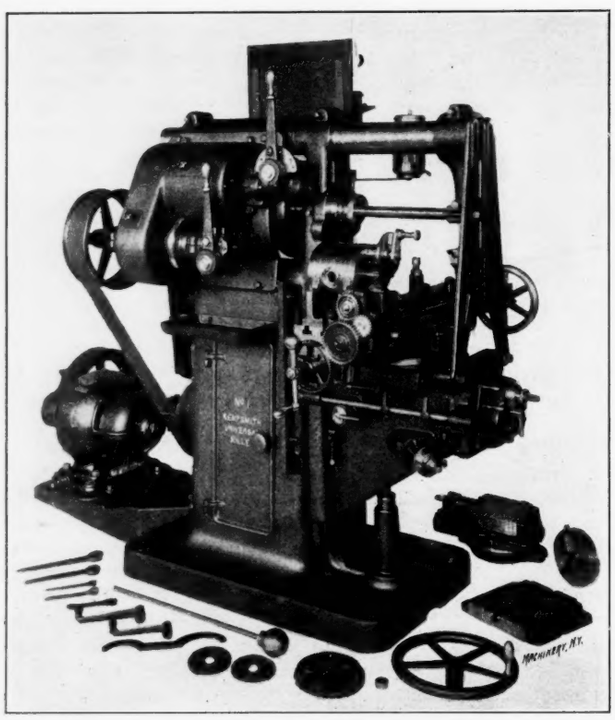
The next convention of the National Machine Tool Builders' Association will meet at Washington on Tuesday, April 11, 1905.

MACHINERY AND TOOLS.

A MONTHLY RECORD OF NEW APPLIANCES FOR THE SHOP.

MOTOR-DRIVEN MILLING MACHINE.

The accompanying illustration shows a new universal milling machine, equipped with a motor drive, which the Kempsmith Mfg. Co., Milwaukee, Wis., have designed and are now building. The motor is of the constant speed type, back geared, and is rated at 1½ horse power; it is mounted on a stand bolted to the main casting. The back gear shaft of the motor is connected to the driving shaft of the machine by belt or silent chain as preferred.



Motor-driven Kempsmith Miller.

The variable speed mechanism on the miller provides a range of sixteen changes, obtained through ring frictions. This method is of advantage in that it permits the combination for any desired speed to be thrown in while the machine is running full, without interfering with its operation. The changes are obtained through levers located at the front of the mechanism. A table of speeds placed on the machine gives the different speeds and data for obtaining same.

All feeds to the table are positive and automatic. The feed gear box is recessed into the column, thus being rigidly supported without any overhanging part. It is driven by sprocket chain direct from spindle, the sprocket wheel being keyed to main spindle. Through the levers shown on the gear box, 16 changes of feed are readily available, in geometrical progression. An index plate on the front of the box shows the entire range and the necessary combination to obtain any desired feed. The levers for reversing all feeds, and for automatically tripping all feeds at any time, are centrally located at front of the knee.

The column, base, and bridge for overhanging arm are cast in a single piece. The starting box is mounted above the machine, where it is securely out of the way.

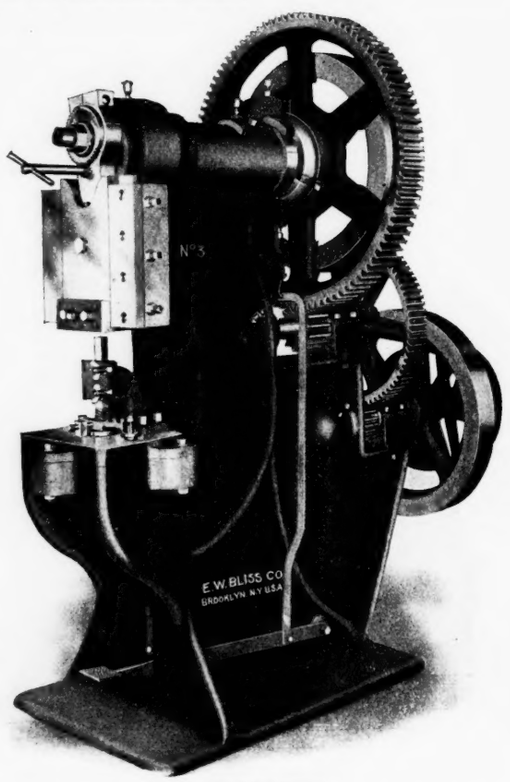
The swiveling table is clamped at any position by an improved bevel clamping ring. The illustration shows the improved construction of side center tailstock which permits the use of large diameter end milling cutters up to within ⅛ inch of the center. This center can be readily elevated for milling tapers. The telescopic elevating screw permits the table to travel to its lowest point without requiring a hole in floor or foundation.

This method of motor drive may be applied to the machine at any time after its completion, as illustrated, or it may be incorporated in the machine while building, in which case the builders are able to render the construction somewhat more compact in appearance.

BLISS BROACHING PRESS.

The E. W. Bliss Co., 5 Adams St., Brooklyn, N. Y., have just brought out a machine which, though resembling the regular Styles power punching press of their manufacture, is a modification of this machine, adapting it to a special purpose. The accompanying illustration shows the novel arrangement of gearing, as well as the work for which the press has been designed.

The press was made especially for broaching and has a distance of 12 inches between the bed and the slide, with the stroke and adjustment up. The stroke of the slide is 3 inches. The flywheel weighs 250 pounds. The ratio of gearing is 36½ to 1. A belt rim is bolted to the large gear, so that when the gearing is disconnected the press may be run singly. Disconnecting the gearing is effected by throwing out of mesh the pinion on the intermediate shaft.



Bliss Broaching Press.

The broaching fixture is shown in position in the half tone view. The broach is so made that it will fall right through the press after the broaching operation. Great saving can be effected by the broaching process in finishing castings and the strong, slow motion of the slide in this press gives very smooth results.

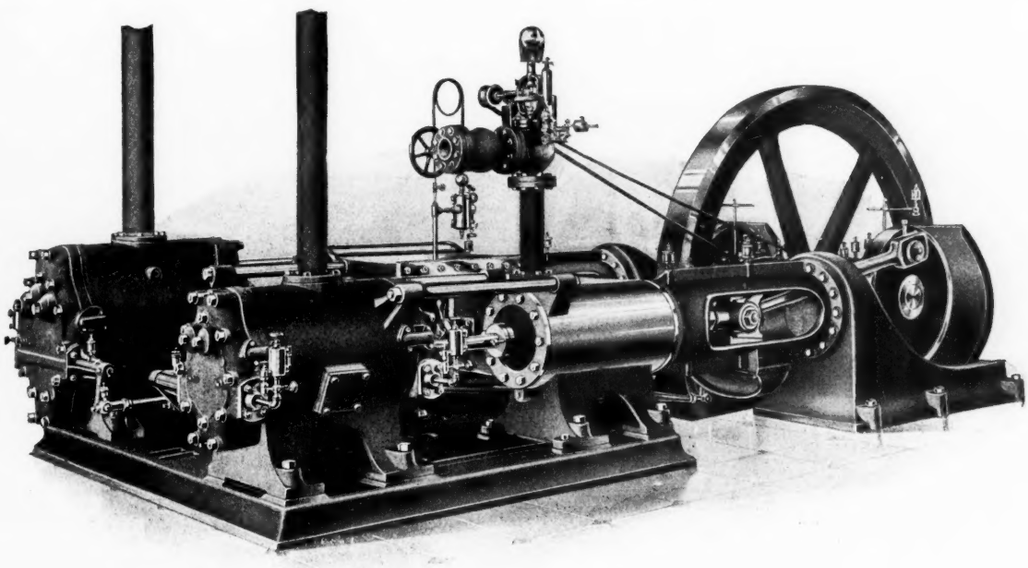
The total weight of the press as shown is 3,800 pounds.

A NEW FRANKLIN AIR COMPRESSOR.

The Chicago Pneumatic Tool Co. have recently built at their Franklin, Pa., plant a number of their latest type of air compressors to be used by the Pennsylvania Railroad in their shops at Altoona. These compressors are furnished with mechanically-operated inlet valves for the air cylinders and Meyer adjustable cut-off valves for the steam cylinders, steam and air cylinders both being compounded. The high and low-pressure steam cylinders are 11 and 20 inches diameter,

respectively, and air cylinders 11 and 18 inches with a stroke of 24 inches. The capacity of each compressor is 700 cubic feet of free air at a speed of 100 revolutions per minute. The steam cylinders are non-condensing, and are designed for a boiler pressure of 100 pounds.

The main steam valves are double-ported, and balanced. The air inlet valves on both air cylinders are of the Corliss type, and are actuated by the steam cut-off eccentrics, so that four eccentrics drive both steam and air valves. The air discharge valves are of the poppet type, and are cup-shaped, pressed out of sheet steel. Valve seats and guides are removable and readily accessible.



New Franklin Air Compressor.

An intercooler is provided between high- and low-pressure air cylinders, which, being self-contained, can be placed wherever it is desired. This intercooler cools the air after compression in the low-pressure cyinder down to the temperature of the atmosphere.

The governor is furnished with a pressure regulator which brings the machine to a stop when the receiver pressure has reached a desired amount, starting it again upon a drop in pressure. The governor is also provided with a safety stop.

Owing to the small bore of cylinders and proportionately long stroke, the percentage of clearance is small. A single sole plate extends under the four cylinders, to which they are doweled, thus aiding in setting up and maintaining alignment.

CINCINNATI BACK-GEARED CRANK SHAPER.

The Cincinnati Shaper Co., Cincinnati, O., have recently redesigned their 16-inch back-geared crank shaper, shown in the accompanying figure. Quite a number of changes have been made in this machine, one of the most notable of which is the increase in the ratio of the gearing, with the back gears in, from 12 to 1 to 24 to 1, making the shaper very powerful. The machine has been strengthened throughout accordingly.

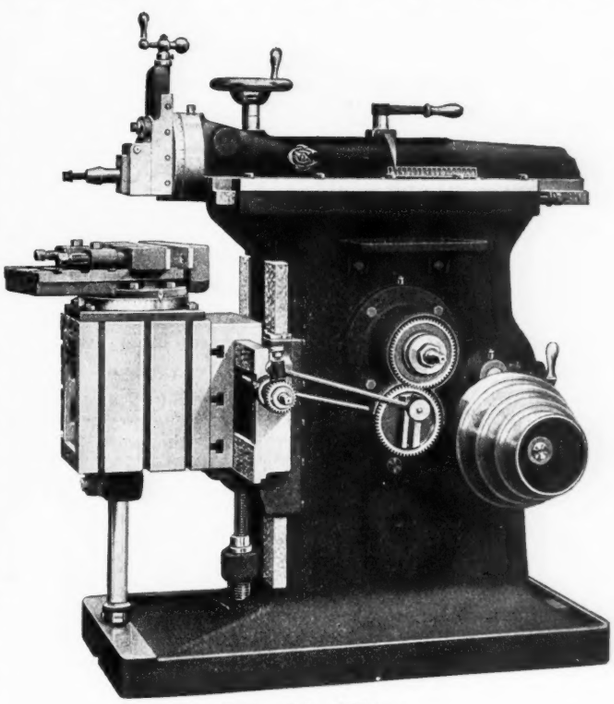
The ram of this shaper may be given eight speeds. It is provided with a bearing in the column 29 inches long by 10½ inches wide, the horns projecting at the front and back of the column allowing this length. The cross traverse screw is provided with a graduated collar reading to .001 of an inch. There are felt wipers between the column and the rail.

The head swivels to any angle and is graduated. The down feed screw is provided with a graduated collar reading to .001 inch. The head is of 8 inches diameter, and may be fed through 7 inches.

The inner end of the main gear journal is twice the diameter of the outer end, thus overcoming any tendency to break at the junction to the gear. The crank block is a steel forging, set well into the cup of the gear, thus permitting the rocker arm to travel close to the edge of the gear and so avoiding overhang.

Full length taper gibs are provided throughout, for the ram, head rail, apron and crank wheel slides, each adjustable endwise by a single screw. The cross feed connecting rod is automatically adjustable to any height of rail and does not depend upon frictional contact. The elevating screw to the rail is of telescopic form, never receding below the floor, and ball bearings are provided for its lower end.

Keyseating of shafting and of similar work, up to 3 inches diameter, is provided for by an opening through the column under the ram. The table is 12 inches long by 11 inches wide. Outer supports, as shown, are furnished. The vise is of double screw form, has a graduated swiveling base, and permits



Cincinnati Crank Shaper.

either straight or taper pieces to be clamped readily. The vise opens 8¼ inches, and the jaw plates are of annealed tool steel.

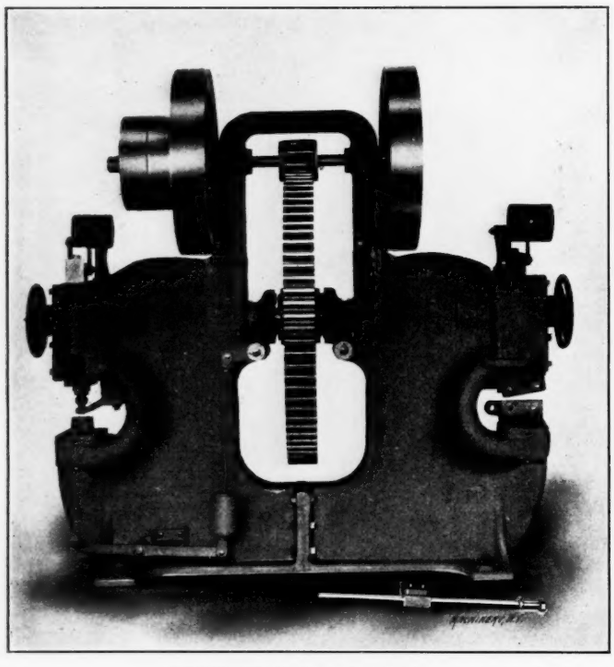
All shafts of the machine are of high point carbon steel, accurately ground; all gears and tee slots are cut from the

solid; all pinions are of cast steel and all bevel gears are cut from the solid bar. All flat sliding surfaces are hand-scraped to surface plates.

The length of the stroke can be changed from the working side of the shaper, and its position by means of a handwheel, shown on top of the ram. These changes can be made while the machine is in motion. The extreme length of stroke is 16½ inches. When the shaper is used single-geared the ratio is six revolutions of the cone shaft to one stroke of the ram. In the back-geared form, the ratio is, as stated above, 24 to 1.

THE DOTY DOUBLE-END PUNCH AND SHEAR.

The accompanying illustration shows a double-end punch and shear recently built by the New Doty Mfg. Co., Janesville, Wis. The machine is seen to be very simple in its design. The main frames are of cast iron of hollow box section. The eccentric shafts are made from open-hearth steel, with the eccentric turned larger than the body of the shaft, thus allowing an extra large bearing in the front cover plate. Eccentric boxes are of bronze, carefully fitted to the sliding heads. These latter are fitted with brass gibs for taking up any wear which may occur.



Doty Double-end Punch and Shear.

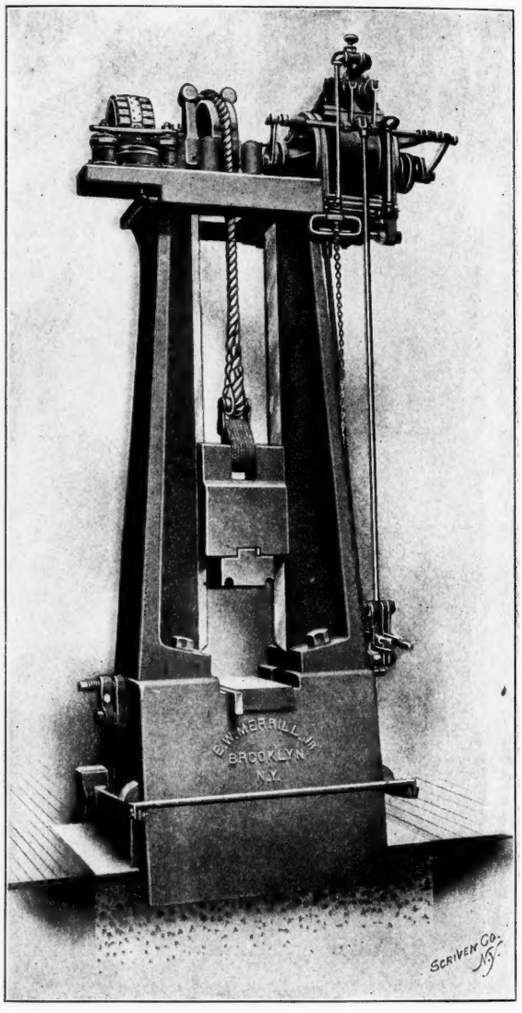
The gear ratio in the Doty punch is seen to be large, and as the flywheels are heavy both ends of the machine may be run continuously. One end of the machine is fitted with punching tools, and the other end with bar shears, but as all classes of tools are interchangeable, this arrangement can be varied as desired.

IMPROVED SEMI-ROTARY STEAM DROP HAMMER.

The accompanying illustration shows the drop hammer manufactured by E. W. Merrill, Jr., Brooklyn, N. Y., as it appears with recent improvements. These consist chiefly in the removal of all trip or hold-up latches, pawls, and falling rods, commonly employed in drop-hammer mechanisms. In their place an automatic brake is applied to the lifting shaft to arrest the hammer the moment the foot of the operator leaves the treadle. By the absence of the working parts mentioned above the hammer is enabled to operate with a nearer approach to noiselessness, and wear and breakages are correspondingly reduced.

The Merrill hammer and lifting device was described in its original form in MACHINERY for January, 1903. As then described the lifting shaft is rotated, through a fraction of a revolution, by a steam or air cylinder at the right end of the shaft. A piston in the cylinder revolves to a certain position, lifting the hammer by means of a rope or strap attached to lifting arms on the piston shaft. At the final piston position the steam or air is allowed to exhaust, the piston returns to its initial position, and the hammer drops by gravity.

The improved lifter holds the hammer suspended at different heights, not by the usual side-latch, as heretofore, but by means of the brake attached to the left-hand end of the lifting shaft. This brake works in conjunction with the main lifting valve, and the instant the lifting shaft stops rotating, the brake is automatically applied, and securely holds the shaft in any desired position. The brake is released at will by a small controlling valve, connected to the treadle by a light chain or rod. By keeping the foot depressed upon the treadle, the hammer will deliver a repeated number of blows until the foot is removed; a single blow can also be gotten. If the treadle is depressed but slightly, a suppressed blow will be delivered.



Improved Merrill Drop Hammer.

If for any reason the supply of steam or compressed air should be turned off, the hammer cannot fall, even should the treadle be depressed, since the steam or air pressure is required to operate the brake controlling valve, before the hammer can fall.

When setting dies, the hammer can be lowered and held permanently suspended in any desired position, or lowered gently until the faces of the dies meet. When the hammer is held at rest in a raised position power is not consumed, as the brake is held in its locking position by compression springs.

The automatic trip may be set at any height between the lowest and highest range of fall by the adjustment of a turnbuckle. This operation may be performed while the hammer is running. The fall may be varied from a drop of six inches up to one of eight feet.

The speed of operation of the hammer depends upon the steam or air pressure. Under ordinary conditions blows will be delivered at the rate of 100 per minute with a 1-foot fall, 75 with a two-foot fall, 60 with a three-foot fall, and greater falls with a proportionately less number of blows.

Heavy hammers are successfully raised by this type of lift. Locomotive forgings weighing 240 pounds each have been formed from the solid with hammers raised in this manner.

These lifters can be placed over any style drop hammer, because the entire operating mechanism is self-contained on the one-bed plate.

NATIONAL TURRET HEAD DRILL CHUCK.

The accompanying half-tone, Fig. 1, shows a turret lathe fitted with a number of the new turret head drill chucks which the Oneida National Chuck Co., Oneida, N. Y., are now

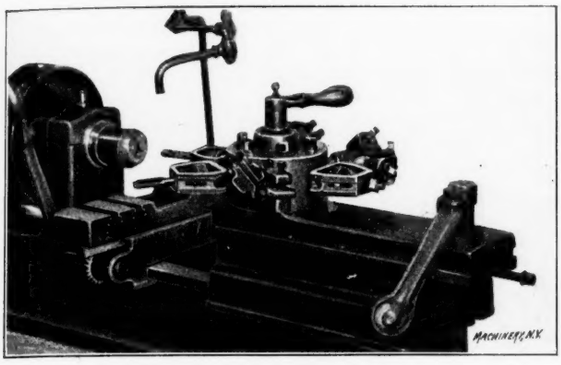


Fig. 1. Lathe with Turret Head Drill Chuck.

making especially for turret head use. One of these chucks is shown in Fig. 2.

The shank of this chuck is made to fit the holder in the turret head. There is a positive drive, in which the end of a

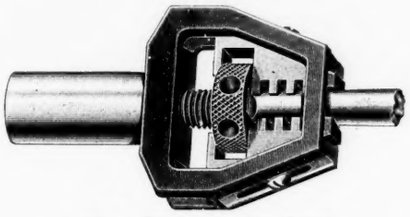


Fig. 2. Turret Head Drill Chuck.

tap or drill is held positively. The flat construction of the chuck allows a larger size to be used in the lathe than otherwise. Its shortness and compact construction are also features.

NEW RIVETT INTERNAL GRINDER.

A new machine designed especially for internal grinding at high speeds of rotation has just been put out by the Faneuil Watch Tool Co., Brighton, Boston, Mass., and is a development of the smaller bench grinder of that firm.

This grinder is designed especially for operation in holes up to 3 inches or 4 inches diameter, although it will swing work as large as 6 inches in diameter. It will also grind to a depth of 6 inches. Its appearance is shown by Fig. 1. The grinding wheel slide may be swiveled to any required angle, and is operated by the handwheel shown at the right front of the cut. The work table, which is also arranged to swivel, has an automatic reciprocating action, and may be traversed by hand through the handwheel shown to the left of the cut, acting through a pinion and rack.

The quill for the grinding wheel spindle embodies the "Rivett" type of bearing, as shown in Fig. 2. In this, end thrust is taken up by the collar centrally located on the spindle. This collar revolves between anti-friction washers abutting against adjustable sleeves. The adjustment of the split bearings is made by means of sleeves which are independently capable of endwise movement through the agency of the opposing screws shown at 1 and 2. Each of these sleeves acts upon three wedges which are concaved at the bottom to fit the box, and which serve to adjust the latter nicely to the spindle, as the sleeve is slid endwise.

The spindle is driven by two elastic belts, through pulleys at each end, as shown in section in Fig. 2, and in perspective in Fig. 1. The speed range secured by the cone pulleys is stated as from 20,000 to 75,000 revolutions of the spindle per minute. The reciprocating mechanism for the table is oper-

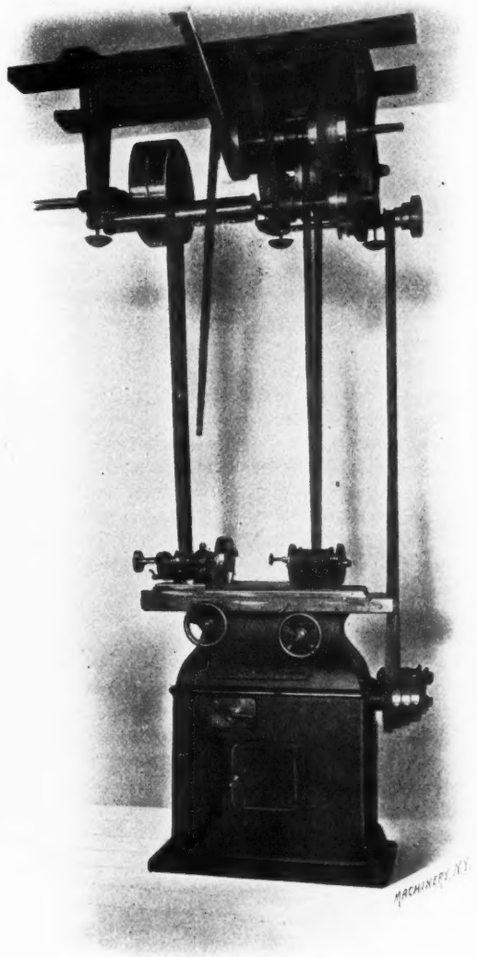


Fig. 1. Rivett Internal Grinding Machine.

ated through a heart-shaped cam carried on a vertical shaft, which cam acts on an adjustable contact roll carried by a rocker arm; the roll is held constantly in contact with the cam by springs. The upper end of the rocker arm is joined by a link to a reciprocating block, which may at will be connected to or disconnected from the work-table.

The cam is of considerable depth and tapers from top to bottom. The length of stroke of the work-table may be varied from 0 up to 6 inches by turning the handle shown at the front of the bed of the grinder, in Fig. 1. This is accomplished by means of a shaft, operated by the handle, which shaft, through bevel gears and screws, adjusts the position of

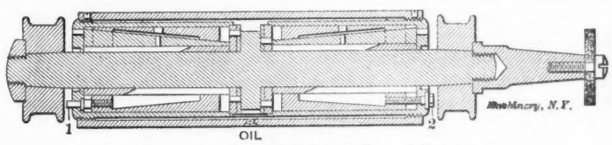


Fig. 2. Grinding Wheel Spindle and Bearing.

the contact roll carrier along the face of the rocker arm. The cam is so laid out that as the center of the stroke is approached, that is, as the grinding wheel nears the middle of the work the rate of traverse is slightly retarded, the movement being correspondingly accelerated immediately the center point is passed. This counteracts any tendency there may be for the wheel to take a lesser cut at the center of the work

than at the ends, and at the same time allows, in general, a coarser rate of feed to be employed than would otherwise be permissible. The cam, which causes the reciprocation of the bed, is rotated from the four-stepped cone shown at the side of the machine, through bevel and spur gearing. The driving belt passes under two idlers mounted directly back of the cones.

The reciprocating block which drives the table is attached thereto by a clamp, which is held in a slot formed in the under side of the table. This construction is designed to prevent the possibility of springing in any working part of the machine. The table may be stopped at once, without shutting down the machine, by releasing this clamp. It may then be run back by hand for the inspection of the work, or the admission of new work.

A stop (not shown) is provided at the left-hand end of the table to act as a locating medium, so that, after the table has been disconnected from the block and run back, it may again be slid forward exactly to its former position. It may then be again clamped to the block and a cut taken by the wheel to exactly the same depth as before. By means of the stop, also, the table and the work upon it may be given any adjustment desired relative to the grinding wheel.

Fig. 1 shows clearly the arrangement of the overhead shafting and cones by which the velocity of the work and wheel spindles, and the speed of reciprocation of the table, may be varied.

NEW STARRETT TOOLS.

The L. S. Starrett Co., Athol, Mass., have brought out a number of new tools for machinists and toolmakers, three of which are illustrated herewith. In Fig. 1 is a new protractor, which also makes a square, plumb and level. The turret which carries the blade is graduated on both sides, one side in degrees and the other to show the pitch to the foot; and the fact that there are two arms to the square enables the complementary angle to be laid out without calculation, if desired. The sliding blade enables the square to be used in close quarters, where a fixed blade could not be used, and the tool is also adapted for use as a depth gage, under certain conditions.

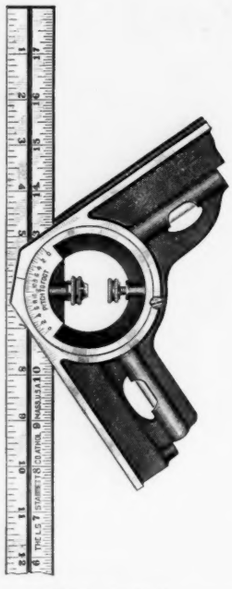


Fig. 1. Protractor.

Fig. 3. Universal Surface Gage.

In Fig. 2 is shown a pair of keyseat clamps, designed to transform any steel scale into a keyseat rule. The clamps are made from steel, casehardened and accurately ground.

In Fig. 3 is a new universal surface gage, with casehardened steel base. The base is grooved through the bottom and end, adapting it for use on or against circular work as well as flat surfaces. The spindle passes through a rotating head jointed to a rocking bracket pivoted in the base. The bracket is adjusted by a knurled screw which acts against a stiff spring. The spindle may be set upright or at any angle, or turned so as to work under the base, and can be delicately adjusted to any position. The scriber is carried by a swiveling head. In the base are four gage pins which can be pushed out to bear against the edge of a surface plate or the side of a planer slot for linear work. The spindle may be removed if desired and the scriber inserted in a hole provided for it for small work.

In their catalogue No. 17 D, describing the new tools recently brought out by this company are a large number of new micrometer calipers which are put up in sets, to measure from 1 to 6 inches. These sets are arranged in various combinations, containing a greater or less number of micrometers, as desired. Numerous other small tools are shown, such as a small tap wrench, nippers, pocket screw drivers, pin vises, etc.

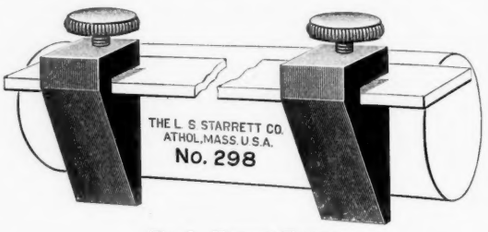


Fig. 2. Keyseat Clamps.

TEN-INCH "STAR" WOOD-TURNING LATHE.

We show in the accompanying cut the 10-inch "Star" wood-turning lathe of a new design which has just been placed on the market. This lathe is especially suited for use in manual training schools. Its rated size is 10 inches, but it has an actual swing of 11 inches over ways and 7 inches over hand rest.

The lathe is fitted with a hollow spindle (with 17-32 inch hole), made from a crucible steel forging, which runs in large phosphor bronze bearings which are dust-proof and self-oiling. The cone pulley has four steps, and is turned inside as well as outside.

Star Wood Turning Lathe.

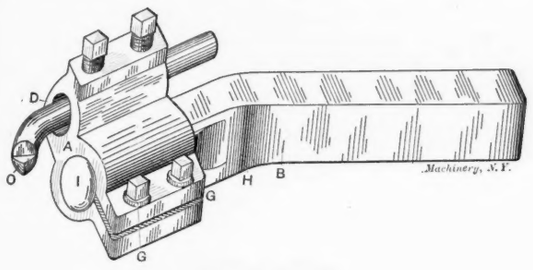
The tailstock is the cut-under pattern, has a long bearing on the ways and is firmly locked to the bed by a convenient lever. The tailstock spindle is locked by an improved locking device. The hand rest has long and short T-rests. The rest socket and saddle are locked to the bed by a cam locking device and the T-rest is held in socket by a friction clamp, thus doing away with the setscrew commonly used. Both are operated by levers.

The bed is made in two lengths, four and five feet long. The front way is flat and the back way is V-shaped. The countershaft has self-oiling and self-aligning shaft bearings, four-step cone and tight and loose pulleys. Faceplate, screw-chuck, cup and spur centers are furnished with each lathe and when desired a slide rest for metal turning.

This lathe is manufactured by the Seneca Falls Mfg. Company, 330 Water Street, Seneca Falls, N. Y.

ADJUSTABLE TOOL-HOLDER.

The adjustable tool-holder illustrated herewith, the invention of J. X. Mathieu and J. F. Pullan, Great Barrington, Mass., provides a device for holding boring tools whereby the latter can be set to the exact length required for the depth of the hole to be bored. By its use also the boring tool can be readily raised or lowered, and brought to its point of application, without losing its horizontal position, by rotating the head, *A*, on the cylindrical portion, *I*, of the shank, *B*. The advantage of keeping the tool parallel to the axis of the hole, especially in boring holes of small diameter, is obvious, as



Adjustable Tool-holder.

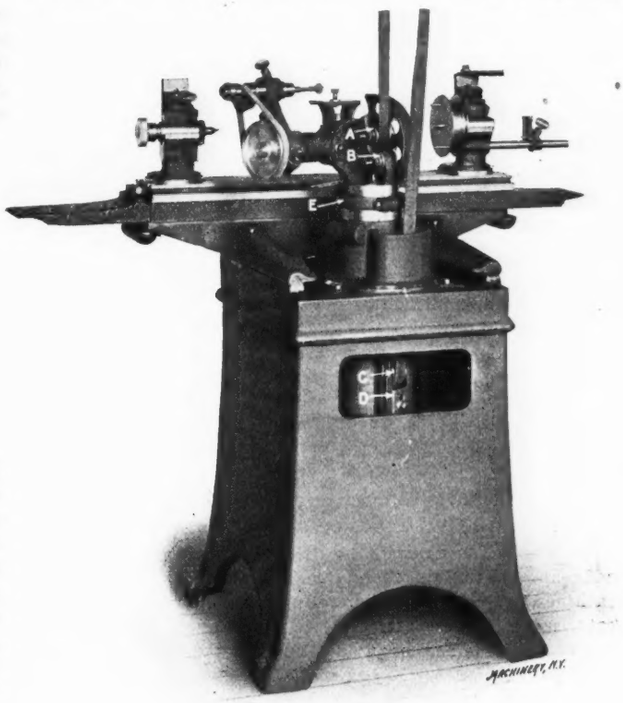
otherwise the largest possible tool could not be used without interfering with the work during the advancement of the tool.

The construction of the tool-holder is evident from the figure. The shank, *B*, of the holder is held in the chuck or tool stock of the lathe. The head, *A*, which carries the cutter 0 securely setscrewed in opening, *D*, is placed on the cylindrical end of the shank of the holder, and clamped to any desired distance above or below the holder, by means of clamp screws, *G*. The shank of the holder is bent, as shown at *H*, so that the tail of the cutting tool may be thrown clear of the tool stock, and the head allowed to rotate without interference.

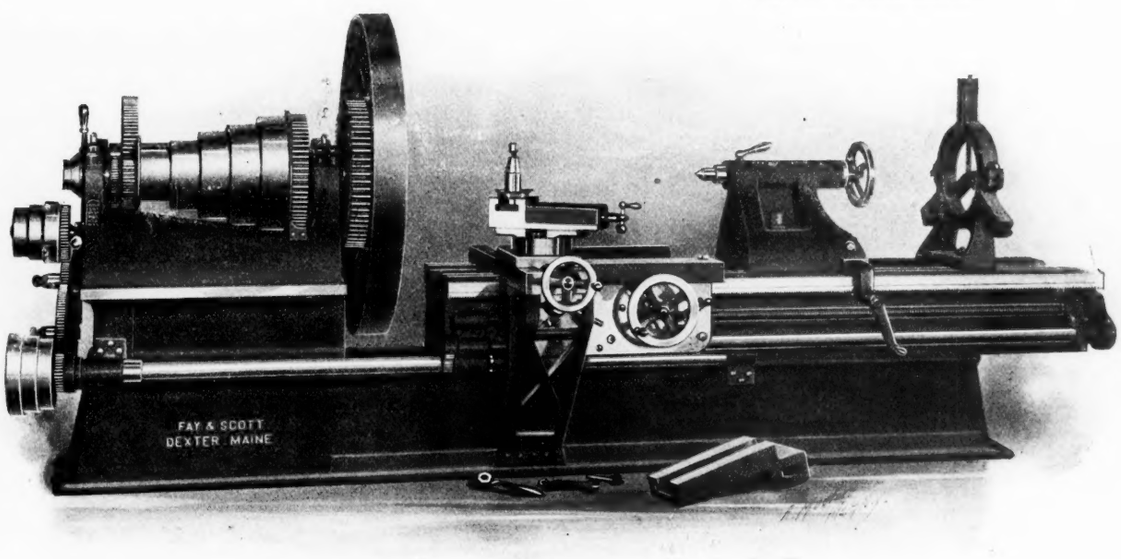
The holders are intended to be made in two sizes, the larger for engine lathe, and the smaller for bench, or precision lathe, work.

IMPROVED DESIGN OF WALKER GRINDING MACHINE.

The accompanying illustration shows the present improved form of the Walker tool room grinder, which was described in MACHINERY for August, 1904. The machine as there illustrated was a universal grinder which combined considerable range of operation with freedom from complexity.



Improved Universal Grinder.



Extension Gap Lathe.

EXTENSION GAP LATHE.

Fay & Scott, Dexter, Maine, are the makers of the extension gap engine lathe illustrated herewith. This lathe is triple geared direct to faceplate, the triple gear ratio being 34 to 1. The carriage is extended for turning work with the full swing of the lathe, and is supported by an angle bracket, with an adjustable gib on the lower bed. The lathe swings over the bed 28 inches, and through the gap 52 inches. The 12-foot lathe made takes 6½ feet between centers closed, and 10½ feet extended. The gap opens 4 feet, and every additional foot of bed lengthens the gap by 6 inches.

An important feature was the arrangement of grinding spindle, wheel post and housing, whereby the spindle could be raised and lowered, and swiveled horizontally and vertically, without affecting the tension of the belt. The changes made consist in an improved design of column for the grinder, but more particularly in an enlarged and improved wheel post and housing, whereby one leg of the belt passes down through the post and around a stationary idler, instead of being outside the housing, as in the previous construction. The range of performance of the grinder remains the same. An improved automatic feed device has also been provided.

In the illustration given, a rear view of the grinder, the method of belting is seen. The down leading side of the belt passes under the upper idler, *A*, around the grinding spindle, over idler *B*, thence down inside the hollow wheel

post and under idler *C*, whence it returns through the opening in the housing, as shown. The idler *C* is journaled in bearings in the vertical slide, *D*, as seen through the opening in the column, by means of which any stretch of the belt may be taken up. No adjustments of this idler are necessary for the ordinary operation of the machine, since the power is all delivered from the down side of the belt, and the spindle is made to raise and lower without varying the belt tension. The down leading side of the belt above the spindle coincides with the axis about which the housing swings, and therefore the running of the belt is not affected by the angular adjustments of the housing. The idler *C* swivels with the housing, and the belt runs in partial or full quarter turn, as the case may be.

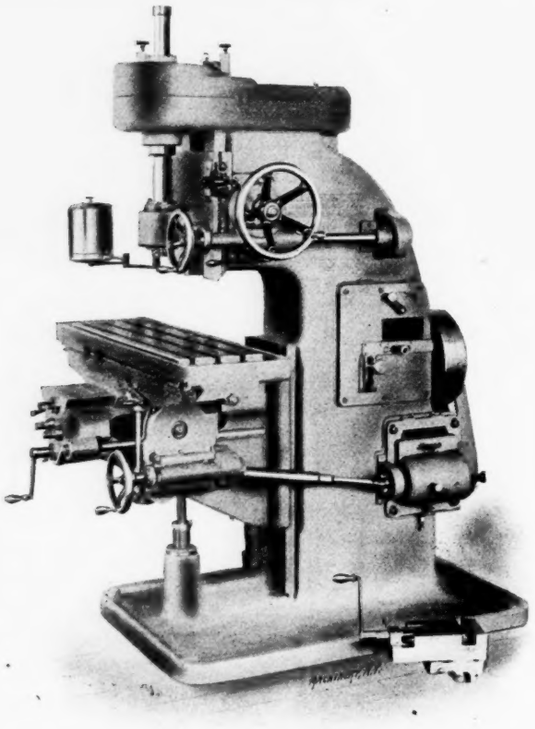
The wheel post is raised or lowered by means of an elevating screw, a pair of miter gears and a horizontal shaft ending in a handwheel on the front of the machine. This horizontal shaft is journaled in a bracket which is free to swivel about the hub at the lower end of the wheel post housing.

A further improvement in the present machine consists in means for setting the milling cutter tooth rest to height without the use of gages. A tooth rest bracket is provided, which, as shown at *E*, rests on top of the housing and is faced off to bring it to the exact height.

The machine is made by the Walker Grinder Co., Worcester, Mass.

NEW BROWN & SHARPE VERTICAL MILLER.

The Brown & Sharpe Mfg. Co., Providence, R. I., have made an addition to their line of vertical spindle milling machines, a tool embodying a number of very interesting features. It is very attractive in appearance, as well, as is evidenced by the accompanying illustration.



New Brown & Sharpe Miller.

A constant speed drive is used in this machine, the cones being done away with. A single 14-inch pulley is used, belted to a countershaft to run constantly at 310 revolutions per minute. The drive is direct from the vertical driving shaft to the vertical spindle by chain and sprocket wheels, insuring a positive drive; the variable speed of the spindle is obtained by gearing that has a ratio of from 1 to 1 up to 18 to 1. Sixteen changes of speed are thus given, or from 17 to 354 revolutions per minute in either direction. The drive can very easily be from a constant-speed motor instead of from the belt pulley, finished bosses being provided on the back of the machine for the attachment of a motor.

The variations of spindle speeds are in geometrical progression, and are controlled by the movement of a lever and index slide on the side of the machine. To change the speed the lever is unlatched, and moved down as far as it will go, when the index slide is moved until it is opposite the column on the speed plate corresponding to the desired speed. The lever is then moved up, and the locking pin engaged with the proper hole, when the correct gears will be in mesh. The lever over the plate gives two series of speeds, one fast and the other slow.

The spindle is of crucible steel with bronze boxes, the lower of which is provided with means for taking up wear. The lower end of the spindle is threaded to receive a large cutter or a chuck, and has a taper hole. A recess across the end provides for positively locking any arbor or collet that has a clutch collar. The arbors and collets are held in place by a drawing-in bolt that passes through the spindle.

The spindle head has a vertical movement with fine hand feed and a quick return; also an automatic feed for drilling work already in position for milling. The feed is automatically released at any point, a micrometer stop being provided to regulate the depth of cut. The head is counterbalanced by weights inside the column.

The table is provided with a quick return obtained through a coarse-pitch screw. To utilize it, the feed worm is disengaged and the crank shown on the face of the knee turned. A slow and powerful hand feed in either direction is given by the handwheel at the right of the machine, which connects with the worm and wormwheel. Ball thrusts are provided for the feed worm and elevating screw, which latter is of the telescopic pattern.

Table feeds are automatic in either direction and can be automatically released at any point, when the table will be locked in that position. With the table feed locked, the power cross feed or vertical feed can be used. The table feed screw is not splined.

The feed mechanism is newly designed, and consists of a chain and sprocket drive from the machine pulley shaft to the feed case, with no intermediate gearing. The feed is thus positive. The gears in the feed case, driven by the chain, are all spur gears, there being 12 changes, varying in geometrical progression from 1½ inches to 17 inches per minute. This method of driving gives a table feed that is independent of the spindle speed, and also a fixed rate of feed, in inches per minute, as shown on the feed index plate. For small mills a range of from .004 inch to .048 inch, and for large mills from .088 inch to 1.000 inch is given per revolution of spindle. To change the feed, it is only necessary to withdraw the locking pin of the lever shown at the right of the feed case, and move up the lever as far as possible; the index slide underneath the table of feeds is then moved opposite the column containing the required feed; the lever is then moved down and the locking pin will drop into the proper hole. The short lever at the bottom of the case gives two series of speeds, one fast and one slow.

The working surface of the table is 42 by 12 inches. The greatest distance between the top of the table and the end of the spindle is 23 inches, the knee having a vertical adjustment and automatic vertical feed of 15 inches, and the spindle head of 8 inches. The automatic longitudinal feed is 34 inches and the transverse 13½ inches.

TOLEDO REDUCING PRESS.

The Toledo Machine & Tool Co., Toledo, O., have recently completed what they claim to be one of the largest and most powerful single pitman straight-sided, cutting, forming and reducing presses ever built. It was designed especially for drawing and reducing metal ⅜ and ¼ inch in thickness for large wagon hubs, valve seats, etc., and also for stamping and embossing.

The clutch mechanism is automatic, and of the three-engagement sliding block type, being controlled by a gravity releasing attachment. The crankshaft is 13 inches in diameter at the crank bearing; the stroke is 14 inches.

The shaft and connection screw are of high-carbon open-

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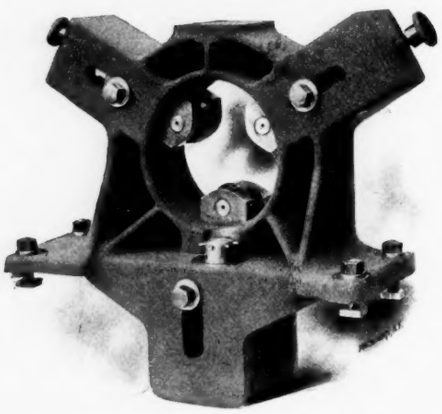
hearth steel forgings. The connection screw for slide adjustment has a right and left-hand thread and is held in position by caps on the upper and lower connections, having a perfect bearing directly on the threads of the screw and securely clamped by means of four studs in each cap. The press is geared 1 to 15, the large gear having a 14-inch face, the teeth being three-fourths diametral pitch. All gears are machine-cut from the solid.

The width between uprights is 38 inches and the area of bed is 38 by 38 inches; the length of slide bearings, 55 inches, and the complete weight of the machine about 95,000 pounds.

HIGH-SPEED FOLLOWER REST.

In the work of roughing bars of even as great as 8 inches diameter some substantial support, such as a follower rest, is needed to obtain the best results from the use of high-speed steels. The illustration herewith shows a follower rest, the invention of the Lodge & Shipley Mche. Tool Co., Cincinnati, O. The company state that after using several different metals for the jaws of such a follower rest, only to have them cut out, they hit upon the roller plan, clearly shown in the half tone. The rollers are of hardened tool steel and are mounted upon hardened and ground steel shafts, upon which they are fixed by screws through the faces of the rollers.



High-speed Follower Rest.

Liberal provision is made for oiling the journals of the roller shafts. A sensitive adjustment for the jaws is provided by the knurled knobs, so that they cannot be forced down too tightly. Provision is also made, at an extra charge, for special cases, so that the pad at the top of the rest can be planed and an angle bracket carried from this to attach to the wings of the carriage on the opposite side, to insure great stiffness and rigidity. So arranged, they say that the results obtainable on heavy bars, from one of their high-speed lathes, can be doubled over the results from the same lathe without such a rest.

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FRESH FROM THE PRESS.

AMERICAN TOOLMAKING AND INTERCHANGEABLE MANUFACTURING. By Joseph V. Woodworth. Published by the Norman W. Henley Pub. Co., 132 Nassau St., New York. 535 8-vo. pages. Illustrated. Price $4.00.

Mr. Woodworth is a toolmaker by trade and has devoted much attention to jigs, fixtures and special devices and appliances for reducing the cost of manufacturing. He has been a frequent contributor to mechanical papers, upon these and allied subjects. In preparing the present volume he has drawn upon information that he has gathered and presented in some 300 contributions to various papers, editing and revising the matter so as to adapt it for a treatise upon improved processes of manufacturing. The volume is illustrated by 600 engravings, made especially for the work, and the typography and press work are good, making an attractive book. The matter is arranged systematically in 33 chapters, treating of subjects related to one another so that it is convenient to have them grouped for reference. Five chapters treat of drilling jigs for various grades of work; milling machine fixtures are treated under four chapter headings; turret lathe tools and fixtures, screw machine tools and boring machine tools each have a chapter; the design and manufacture of milling cutters, the hardening and tempering of such cutters and the making of drills, forming tools, etc., are treated.

In addition to the above there are a number of special lines of work properly coming under the title of the book, which receive attention. These are broaches and broaching; punches and dies; with a somewhat extended treatment of sheet metal work; engraving, the sinking and the use of dies for medals, jewelry and art goods; and finally the process of swaging and the use of swaging machines.

The foregoing titles give a fair idea of the scope of the work, and the seeker after information upon shop processes will find, in addition to the above, that considerable data has been gathered on novel methods for metal working, not commonly known, including processes for working aluminum. The author has made a careful and systematic study of machine shop manufacturing operations, extending over a period of a number of years, and his text book cannot fail to interest persons connected with shops where modern methods of interchangeable manufacturing are in vogue.

NEW TRADE LITERATURE.

Manufacturers and others sending catalogues for notice are requested to address them to the Editor of MACHINERY, so that they can be kept separate from catalogues sent us for other purposes.

JOSEPH DIXON CRUCIBLE Co., Jersey City, N. J. Advertising card calling attention to Dixon's flake graphite for the lubrication of air compressors.

THE ADAMS Co., Dubuque, Iowa. Illustrated catalogue describing the "Adams-Farwell" motor car, recently shown in the columns of MACHINERY.

THE DESMOND-STEPHAN MFG. Co., Urbana, O. Pamphlet treating of the "Desmond" diamo-carbo emery wheel dressers for truing and shaping grinding wheels.

THE LUCAS MACHINE TOOL Co., Cleveland, O. Circulars describing the No. 1 "Precision" boring, drilling and milling machine and the Lucas power forcing press.

THE RAND DRILL Co., 128 Broadway, New York. Circular No. 14 of the "Imperial" pneumatic hammers, piston air drills and air compressors of their manufacture.

THE ELECTRIC CONTROLLER & SUPPLY Co., Cleveland, O. Bulletins Nos. 1004 and 1010 treating respectively of solenoids and electromagnets, and of magnetic switches.

BROWN & SHARPE MFG. Co., Providence, R. I. "Accuracy Measuring Tools," a little pamphlet showing the measuring tools of this company which were exhibited at St. Louis.

THE F. BISSELL Co., Toledo, O. Circulars of the "Acme" metal saw, the "Security" induction sparker for gas and gasoline engines, Bryan-Marsh Imperial lamps for electric lighting purposes, etc.

THE SEATTLE MACHINE WORKS, Seattle, Wash. Circular of the "Paulson" pump cylinder reducing sleeve, designed especially for converting a standard steam boiler feed pump into a high-duty pump.

THE PEDRICK-SMITH Co., Philadelphia, Pa. Unique little catalogue in the form of a punch, showing the punches, dies, punch couplings, etc., made. A list of sizes of each product is given, and some tables also appear.

THE COLBURN MACHINE TOOL Co., Franklin, Pa. Catalogues descriptive of their 53-inch vertical boring and turning mill, and of their 72-inch widened pattern vertical boring mill, described in our December issue.

THE D. M. STEWARD MFG. Co., Chattanooga, Tenn. Circular calling attention to the company's "Compo" and Soapstone marking crayons, for marking car trucks, freight cars, and for a great variety of other purposes.

THE BESSEMER GAS ENGINE Co., Grove City, Pa. Illustrated catalogue of the Bessemer gas engines, gas cylinders and roller pumping powers. A description of each of these products appears, accompanied by many fine half-tone engravings.

THE NEWHALL CHAIN FORGE & IRON Co., New York. Catalogue No. 185, dealing with the "Warwick" chain for all purposes where chain is used, such as for crane work, dredging, steam shovels, ship cables, conveying, mining, quarrying, etc.

THE MOLINE TOOL Co., Moline, Ill. Catalogue No. 1 showing five sizes of gang drills, an automatic screw driving machine, a head borer, a double-end bolt cutter, the R. & V. speed lathe, the R. & V. countershaft, and a gang borer, with short descriptions of each.

THE GENERAL PNEUMATIC TOOL Co., Montour Falls, N. Y. Bulletin No. 56, descriptive of the electric hoist of their manufacture. Other bulletins treat of their portable compression riveter; column riveting machine; combined stationary and portable riveter; and pneumatic motor hoists.

THE NORTHERN ENGINEERING WORKS, Detroit, Mich. Booklet No. 19, of cranes. These include electric, hand, and air-hoist traveling cranes; jib cranes, electric, pneumatic and hand; truck cranes. pillar cranes; locomotive, bracket jib and gantry cranes, illustrated by about twenty-six cuts.

THE L. S. STARRETT Co., Athol, Mass. Supplement to catalogue No. 17D, showing some of the Starrett tools, among which we note a patent protractor No. 16, a keyseat clamp, a tap wrench, a double-lip countersink, a new desk rule, new universal surface gage, a line of new micrometers from 1 to 6 inches, etc.

THE REED MFG. Co., Erie, Pa. Catalogue F of the Reed products. These include stocks, with adjustable and with solid dies; pipe vises, combination vises, pipe cutter wheels, pipe reamers and taps, combination drill and tap, combination pliers, pipe wrenches, the "Economy" oil cup, etc. Some useful tables and other information also appear.

THE OHIO PULLEY Co., Marion, O. Illustrated catalogue, pocket size, of the Buckeye wood split pulleys. All pulleys are bored to a large standard size and with this company's interchangeable wood bushing system each pulley will fit any size shaft up to its standard bore. The various sizes of pulleys are here shown and described and a very complete price list given.

THE DRESES MACHINE TOOL Co., Cincinnati, O. Small catalogue of the "Simplex" radial drills. The chief features of this type of tool are here described, then follow illustrations of four sizes of this tool, with specifications; also cuts of their combination tilting table with worm movement, their speed variator, and their constant-speed and variable-speed motor drive.

THE SPRINGFIELD MACHINE TOOL Co., Springfield, O. Illustrated loose-leaf catalogue, 1905, of machine tools. This book is 9 x 12 inches, and contains, printed on heavy coated paper, illustrations of their engine lathes, a turret lathe, shafting lathe, several sizes of crank shapers, a spindle and axle boring machine, two special turret lathes, two sizes of power presses, etc., with full description of each.

THE GOODELL-PRATT Co., Greenfield, Mass. Catalogue No. 7, 1905, of small tools. Besides the regular line of tools to be found in their previous catalogues a very large number of new tools are here shown, and also a number of old ones that have been changed and improved. This book is standard size and contains 176 pages, all devoted to the illustration and description of this extensive line of tools.

BAKER BROS., Toledo, O. Catalogue No. 4B of drilling, boring and tapping machinery. Several sizes and styles of tapping machines and heavy manufacturing drill presses are shown; also a two-spindle locomotive rod boring machine, which is built in three sizes, and a car-wheel boring machine. A review of this catalogue will show the recent improvements which have been made on this company's machines, considerably increasing the capacity of these tools.

THE DODGE MFG. Co., Mishawaka, Ind. "The Construction of a Modern Cement Plant." This is a book 9 x 12, consisting of 75 pages, and treating the subject of cement plants. There are a large number of half-tone views of various cement plants in which is installed the transmission machinery of the Dodge Company. This book is not for indiscriminate distribution, but to those who are genuinely interested a copy will be sent free upon request.